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NWP 55-3-AH1
VOLUME I (Rev. B)
NAVAIR 01-110HC-1T

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NWP 55-3-AH1
VOLUME I (Rev. B)
NAVAIR 01-110HC-1T

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June 1986

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1. NWP 55-3-AH1, Vol. I (Rev. B) (NAVAIR 01-110HC-1T), the AH-1 TACTICAL MANUAL, is an Unclassified publication which is effective upon receipt. It supersedes NWP 55-3-AH1, Vol. I (Rev. A) (NAVAIR 01-110HC-1T) of August 1980, which shall be destroyed without report.

2. Aircraft tactical manuals provide the latest and most accurate tactical information to aircrews and tactical commands. These manuals are designed to promote the development of efficient and sound tactical doctrine and to eliminate the need for promulgation of doctrine by individual squadrons. The tactics published herein are to be considered as a guide to better operations, not as the only way and final authority in tactical evolutions. It is both desirable and necessary that new ideas and new techniques be expeditiously evaluated and incorporated if proven to be sound. To this end, Operational Commanders should encourage innovative thought and the use of effective tactics not reflected herein. These manuals are compiled using Fleet inputs and are kept current to achieve maximum combat readiness. To provide the latest data, Navy and Marine Corps Fleet/Type/Air Wing Squadron Commanders are directed to review these procedures on a continuing basis and submit recommended modifications as outlined under "Change Recommendations."

LA Edney
L.A. EDNEY
Rear Admiral, U.S. Navy
Assistant Deputy Chief of Naval Operations
(Air Warfare)

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3. The AH-1 Tactical Manual is intended to be used in conjunction with NWP 55-9-ASH, Assault Helicopter Tactical Manual, Volume I (U), Volume II (S), and Pocket Guide (U).

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BIBLIOGRAPHY

FM1-40, Attack Helicopter Gunnery

FM1-60, Airspace Management and Army Air Traffic In a Combat Zone

FM1-100, Army Aviation Utilization

FMFM-3, Joint Munitions Effectiveness Manual

FMFM-3-3, Helicopterborne Operations

FMFM-5-1, Marine Aviation

FM-9-6, Ammunition Service In the Theater of Operations

FM10-67, Petroleum Supply In Theaters of Operation

FM10-68, Aircraft Refueling

FM17-40, Attack Helicopter Gunnery

FM17-47, Air Cavalry Combat Brigade

FM17-50, Attack Helicopter Operations

FM90-1, Employment of Army Aviation Units in a High Threat Environment

FM100-42, U.S. Air Force/U.S. Army Airspace Management in an Area of Operations

JCS PUB I, Extract for CV-10 Tactics Handout

NAVAIR 01-H1AAA-1, AH-1T NATOPS Flight Manual

NAVAIR 01-H1AAA-75, AH-1T Airborne Weapons/Stores Loading Manual

NAVAIR 01-40-AV-1T, A-4 Tactical Manual

NAVAIR 01-45AAA-1T, A-7 Tactical Manual

NAVAIR 01-110HC-1T, Attack Helicopter Tactical Manual

NAVAIR 01-110HCB-1, AH-1J NATOPS Flight Manual

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NAVAIR 11-1-117, Identification of Ammunition

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NAVAIR 11-75A-50, LAU-61A Airborne Rocket Launcher; Operation Instructions

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TC1-60, Forward Refueling and Rearming Point Operations

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U.S. Air Force OV-10A, Non-Nuclear Conventional Delivery Manual

VX-5 AEN F/O 210, War-at-Sea

GLOSSARY

A

AAA. Antiaircraft artillery.

AAW. Antiair warfare.

acquisition. The process of locating a target with a search radar such that a tracking radar can take over and begin tracking the target.

acquisition and tracking radar. Radar set which locks onto a selected signal and tracks the object emitting or reflecting the signal.

active electronic countermeasures. The impairment of enemy electronic detection, control, or communications devices/systems through deliberate jamming or deception.

ADA. Air Defense Artillery to include all weapons, guns, surface-to-air missiles, and support equipment, for engaging air targets from the ground.

AHC. A PQM that has demonstrated the ability to accomplish all tactical maneuvers through the combat qualified stage of training in accordance with current tactical doctrine.

AIM. Air-launched, intercept-aerial, guided missile.

air officer (AO). An officer (NA/NFO) attached to a ground unit who functions as a primary advisor to the ground commander on air operation manners.

air support radar team (ASRT). A subordinate operational component of a tactical air control system which provides all-weather, ground-controlled, precision flightpath guidance and weapons release.

air-to-ground missile (AGM). A missile launched from an airborne carrier to impact on a surface target.

airborne radio relay. A technique employing aircraft fitted with radio relay stations for the purpose of increasing the range, flexibility, or physical security of communications systems.

aircraft infrared signature. The infrared signature of an aircraft is determined by the sum of all heat sources (mechanical, electrical, and solar) such as engine exhaust, gearboxes, reflection from windows and wind screens, reflective paint and lights.

airspace coordination area (ACA). The ACA is a three-dimensional block of airspace in which friendly aircraft are reasonably safe from friendly surface fires.

altitude line. Heavy band of clutter produced by radar energy reflection from the earth's surface.

amphibious objective area (AOA). A defined geographical area within which is located the area or areas to be captured by the amphibious task force. It is delineated in the initiating directive in terms of sea, land, and airspace.

amphibious task force. A combined force of Naval and Marine elements task organized for the general requirement of an amphibious operation, and whose capabilities are a function of its size and organization.

amphibious task force commander (CATF): The designated senior Naval officer within the task force who is responsible for the overall operation of the task force.

angle of ttack (AOA). The angle between the FRL and flightpath.

angle off. The angle between the longitudinal axis of a defender and the line of sight of an attacker.

antenna train angle. The angular measurement between interceptor heading and the bearing to target.

area target. A target consisting of an area rather than a single point.

ARM. Antiradiation missile.

armed helicopter escort. A helicopter armed for suppressive fire and flown in support of transport helicopters, utility helicopters, motorized or troop convoys, and other missions to which they may be assigned.

arming. As applied to fuzes, the changing from a safe condition to a state of readiness for initiation.

arming delay. The time interval between the instant a bomb is launched and the instant the fuze becomes armed.

arming device. Device for arming a fuze under controlled conditions.

arming wire. A wire inserted in a weapon fuzing system which, when removed, will allow arming of the weapon fuze(s).

assault support. A Marine Corps term indicating those actions required for the airlift of personnel, supplies, and equipment, into or within the battle area by helicopters or fixed-wing aircraft. Assault support includes fixed-wing transport, in-flight refueling, and helicopterborne operations; such operations may be tactical, administrative, or logistic in nature. The tasks of assault support are vertical assault airlift, air delivery, in-flight refueling, and air evacuation.

assault support helicopter. A helicopter which moves assault troops, equipment, and cargo into an objective area and which provides helicopter support to the assault forces.

authenticate. A challenge given by voice or electrical means to attest to the authenticity of a message or transmission.

B

battalion landing team (BLT). In an amphibious operation, an infantry battalion normally reinforced by necessary combat and service elements; the basic unit for planning an assault landing.

beam intercept. An intercept in which the track crossing angle at missile launcher is between 60° and 120°.

beam rider guidance. That form of missile guidance wherein a missile, through a self-contained mechanism, automatically guides itself along a beam.

BLU. Bomb live unit.

bogey. An air contact which is unidentified but assumed to be enemy.

bomb damage assessment (BDA). A judgment to the extent of a bomb damage, either physical or economic; the procedure involved in making this judgment.

boresighting. The process by which the optical axis of the sight are made parallel to the boreline axis of the weapon.

break turn. An instantaneous maximum performance turn to destroy the enemy tracking solution. The break should be modified by direction and type of threat - break left/right - guns, SAM, AAA, etc.

breakup point (BP). Breakup point is an air control point at which helicopters returning from an LZ break formation and are released to return to individual ship(a) or are dispatched for other employment. The breakup point may be the same point, geographically, as the departure point.

burst override. The use of a short, concise radio transmission which will override enemy jamming while communicating with a station a short distance away.

buster. Used by a ship controller to direct a helicopter to proceed at maximum speed.

C

called turn. Used primarily for general cruise changes when in a tactical formation such as combat spread for look out and control.

CBU. Cluster bomb unit.

CEOI. Communication electronic operating instructions.

CEP. Circular error probability; radius of a circle which includes 50 percent of weapons ordnance impacts.

chaff. Radar confusion reflectors, which consist of thin, narrow metallic strips of various lengths and frequency responses, used to reflect echoes for confusion purposes.

charge, shaped (SC). An explosive charge with a shaped cavity which is lined with a thin metal, ussually copper. On detonation, the metal channels the blast into a long, high speed jet which has considerable arm or penetration capabilities

checkpoint. A landmark that is selected along or adjacent to the flight route and used to fix an aircraft's position.

CIC. Combat information center.

close air support (CAS). Air action against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces.

command and control aircraft (C & C). A tactical mission aircraft for the use of the HC(A) and helicopterborne unit commander to coordinate and control tactical helicopter assaults, troop movements, commander's reconnaissance, and other related missions.

composite squadron. The task organized unit of Marine aviation within a landing force to provide air assets for the landing force commander.

contour flight. Flight at low altitude conforming, generally, and in close proximity, to the contours of the Earth. Characterized by a varying airspeed and varying altitude.

control point (CP). Control point is a position marked by a buoy, ship or craft, aircraft electronic device, or conspicuous terrain feature which is used as an aid to navigation and control of helicopter's en route.

covering patterns. A pattern selected by the gunship flight leader with regard to terrain, weather, friendly and enemy situation which provides maximum cover for the transport helicopter during its approach, landing, or departure phase of operation. Selected patterns should provide maximum area neutralization through the combination of potential firepower and overlapping fields of fire.

D

data link. A communication link suitable for transmission of data.

departure point (DP). Departure point is in an air control point at the seaward end of the helicopter approach route system from which helicopter waves are dispatched along the selected approach route to the initial point.

DF. Direction finding.

direct air support center (DASC). A subordinate operational component of a tactical air control system designed for control and direction of close air support and other tactical air support operations and is normally collocated with fire support coordination elements.

Doppler effect. The phenomenon evidenced by the change in the observed frequency of a sound or radio wave caused by a time rate of change in the effective length of the path of travel between the source and the point of observation.

Doppler radar. A radar system which differentiates between fixed and moving targets by detecting the apparent change in frequency of the reflected wave due to motion of target or the observer.

drop zone (DZ). A specified area upon which airborne troops, equipment, or supplies are airdropped.

E

effective range. The maximum distance at which a weapon may be expected to inflict casualties or damage.

electronic counter-countermeasures (ECCM). That division of electronic warfare involving actions taken to ensure friendly effective use of the electromagnetic spectrum despite the enemy's use of electronic warfare.

electronic countermeasures (ECM). That division of EW involving actions taken to prevent or reduce an enemy's effective use of the electromagnetic spectrum.

electronic intelligence (ELINT). The intelligence information product of activities engaged in the collection and processing for subsequent intelligence purposes, of foreign, non-communications, electromagnetic radiations emanating from other than nuclear detonations or radioactive sources.

electronic warfare (EW). Military action involving the use of electromagnetic energy to determine, exploit, reduce, or prevent hostile use of the electromagnetic spectrum and action which retains friendly use of the electromagnetic spectrum.

electronic warfare support measures (ESM). That division of electronic warfare involving actions taken to search for, intercept, locate, and identify immediately radiated electromagnetic energy for the purpose of immediate threat recognition. Thus ESM provides a source of information required for immediate action involving ECM, ECCM, avoidance, targeting, and other tactical employment of forces.

electro-optics (EO). The interaction between optics and electronics leading to the transformation of electrical energy into light, or vice versa, with the use of an optical device.

emission. Radio waves radiated into space by a radio transmitter or the process of ejecting electrons from the surface of a material under the influence of heat, radiation, or other courses.

emission control (EMCON). A restriction placed on the use of transmitting equipment (all types of emitting devices such as radar, radio, IFF, radioscope, beacons, altimeters, and so forth) for the purpose of reducing the likelihood of enemy interception or deception.

essential elements of information (EEI). The critical items of information regarding the enemy and his environment needed by the commander by a particular time to relate with other available information and intelligence in order to assist him in reaching a logical decision.

evasive maneuvers. Defense maneuvers that have been established through various studies. These maneuvers allow the Aircraft Commander to operate the A/C against a particular threat, and if done successfully would increase the possibility for survival and mission success. The maneuvers are divided into four (4) categories: EVM vs AAA, EVM vs SAM, EVM vs Fixed Wing, EVM vs Armed Helicopters.

F

FAC(A). A FAC(A) is an air controller airborne in the area of operations in a helicopter or fixed-wing aircraft.

fire support coordination center (FSCC). A single location in which are centralized communication facilities and personnel incident to the coordination of all forms of fire support.

firing points. Positions occupied by individual attack helicopters in order to engage targets. Firing points are located in the attack position.

flight coordinator. An experienced gunship commander of the escort flight is normally designated by the Helo Transport Commander to coordinate assets during the insert and extract of transport helicopters.

flight leader. An AHC or HAC so designated in writing the helicopter unit commander. In flights including escorts, the overall flight leader is the helicopter transport commander.

forward air controller (FAC). An officer (NA/NFO) member of the tactical air control party who, from a forward position, controls aircraft engaged in close air support of ground troops.

forward edge of the battle area (FEBA). The foremost limits of a series of areas in which ground combat units are deployed, excluding the areas in which the covering or screening forces are operating, designated to coordinate fire support, the positioning of forces, or the maneuver of units.

forward line of own troops (FLOT). A line which indicates the most forward positions of friendly forces in any kind of military operation at a specific time.

fuselage reference line (FRL), water line, armament datum line. A longitudinal reference line of the aircraft that is fixed by boresight fittings.

G

GAIL. A helicopter portable lighting set composed of one Glide Angle Indicator Light (GAIL) and eight airfield emergency portable marker lights, utilized to assist helicopters in conducting safe landings over hazardous obstacles during periods of darkness.

GBU. Guided bomb unit.

GCI. Ground-controlled intercept.

ground alert. That status in which aircraft on the ground/deck are fully serviced and armed with combat crews in readiness to take off within a specified short period of time (usually 15 minutes) after receipt of a mission order.

gun target line. An imaginary straight line from the gun(s) to the target.

H

H-hour. The specific hour on D-day on which hostilities commence. When used in connection with planned operations, it is the specific hour on which the operation commences.

HE-T. High-explosive with tracer.

HEI-T. High-explosive incendiary with tracer.

helicopter aircraft commander (HAC). A qualified pilot in command of a multipiloted helicopter (CH46 or CH53).

helicopter coordinator (airborne) HC(A). A highly experienced senior aviator operating from a command and control aircraft for the purpose of direct airborne coordination and control of helicopterborne assaults. The HC(A) is responsible for the airborne control of all helicopters and fixed-wing aircraft participating in and supporting a landing. The helicopter transport commander will act as HC(A) when an HC(A) has not been assigned.

helicopter direction center (HDC). The primary helicopter controlling agency aboard a LPH/LHA. It serves to direct and control helicopter missions during shipboard operations and until control of helicopters has been passed ashore.

helicopter transport commander. An experienced aviator in command of the transport helicopters taking part in a helicopterborne mission. He may function as the HC(A) in assaults when no HC(A) is assigned.

helicopter unit commander. The senior Marine aviator designated commander of the helicopter unit who is responsible for its performance.

helicopter wave. One or more helicopters grouped under a single leader and scheduled to land in the same landing zone at approximately the same time. A helicopter wave is composed of one or more flights and can consist of helicopters from more than one ship.

helicopterborne assault. The landing of helicopterborne forces within or adjacent to an objective area for the purpose of occupying and controlling the objective area and positioning units for action against hostile forces.

helicopterborne unit commander (HUC). That ground officer who has been designated to be the commander of the helicopterborne force and who is charged with the accomplishement of its ground mission.

high frequency (HF). 3 MH_Z to 30 MH_Z.

high- to medium-altitude air defense (HIMAD). HIMAD is provided by long range weapons that are deployed in small numbers to cover relatively large areas. Examples of HIMAD SAM's include the SA-2 GUIDELINE and SA-4 GANEF, which have roles similar to the NIKE-HERCULES. These systems have been developed to provide air defense up to the service ceiling of most combat aircraft but also have a capability as low as 1,000 to 1,500 feet. Mobility of these systems varies with the individual design.

HOG configuration. Helicopter configured with four loaded 19 tube rocket launchers and full load of turret ammunition.

holding area. Positions occupied by attack helicopters during the time that FACs and FAC(A)s are searching for targets.

holding point. A site that may be occupied by assault support helicopter for short intervals while escort helicopters evaluate further forward movement of the flight.

hostile area. Area of known enemy concentration where intense operation can be expected. It differs from an insecure area in that no friendly forces are in the immediate area, landing zones are unprotected, and normally fixed-wing prep is mandatory.

I

initial point (IP). Initial point is the final control point in the vicinity of an LZ from which individual flights are directed to their prescribed landing sites.

initial terminal guidance. A mission normally assigned to reconnaissance units to provide the HC(A) with information resulting from prelanding reconnaissance. They establish and operate signal devices for guiding the initial helicopter waves from the IP to LZ.

interference. Any electromagnetic disturbance which interrupts, obstructs, or otherwise degraders or limits the effective performance of electronics or electrical equipments.

intervalometer. An electrical device used in releasing/firing weapons at a constant predetermined time interval between releases.

intrusion. The intentional insertion of electromagnetic energy into transmission paths in any manner with the objective of deceiving operators or causing confusion.

IR. Infrared.

IRCM. Infrared countermeasures.

J

jamming. The deliberate radiation, reradiation, or reflection of electromagnetic energy with the objective of impairing the use of electronic devices, equipment, or systems being used by an enemy.

L

L-hour. The time of landing of the first wave of a helicopterborne unit.

landing force commander (CLF). The designated senior Marine commander (air or ground) who is responsible for the landing force.

landing point. A point within a landing site where one helicopter can land.

landing site. A particular area in an LZ designated by the helicopterborne unit commander to land subordinate units in specific loactions.

landing zone (LZ). A specified zone within an objective area used for the landing of assault aircraft.

landing zone preparation. A mission conducted in preparation for a helicopterborne landing. It is used to neutralize areas in and around the zone, to clear the zone of obstacles, and to destroy booby traps.

LAU. Launcher, aircraft unit.

launcher angle. The angle between the launcher line of a rocket and the FRL.

launcher line. The longitudinal axis of the launcher.

LGB. Laser guided bomb.

letter of instruction (LOI). Used in the higher echelons of military service to convey broad aims and strategic plans or general policy guidance of an operational nature not suited for promulgation in an operational plan or order. It has the same authority as an operational plan or order. While there is no prescribed format for the LOI, because of it's nature, it generally follows the sequence of an operation plan or order to the extent practicable.

line of sight (LOS). The line from the eye to the aiming point, through the optical sight.

low frequency (LF). 30 kHz to 300 kHz.

low-level flight. Flight conducted at a selected altitude at which detection or observation of an aircraft or of the points from which and to which it is flying is avoided or minimized. The route is preselected and conforms generally to a straight line and constant airspeed and indicated altitude.

low threat environment. An unsophisticated antiair threat which consists primarily of small arms fire from infantry weapons, including large caliber automatic weapons, and which is dependent on visual target acquisition and fire control techniques.

low- to medium-altitude air defense (LOMAD). LOMAD is provided by medium-range weapons. The capabilities of systems employed in this role fill the gap between HIMAD and SHORAD. Some LOMAD missile systems include the SA-3 GOA and SA-6 GAINFUL which are similar to the U.S. HAWK. These systems, developed to provide a counter against enemy high-performance aircraft flying at low and medium altitudes, also have a capability against targets above terrain flying altitudes.

M

MANPAD. This classification covers man-portable missile systems intended for the protection of forward area point targets as an attrition weapon against low-flying aircraft. A system fulfilling this role is the SA-7 GRAIL which is similar to the U.S. REDEYE.

Marine air command and control system (MACCS). A United States Marine Corps tactical air command and control system which provides the tactical air commander with the means to command, coordinate, and control all air operations within an assigned sector and to coordinate air operations with other services.

Marine air control squadron (MACS). The component of the Marine air control group which provides and operates ground facilities for the detection and interception of hostile aircraft and for the navigational direction of friendly aircraft in the conduct of support missions.

Marine air support squadron (MASS). The component of the Marine air control group which provides and operates facilities for the control of support aircraft operating in direct support of ground forces.

Marine amphibious brigade (MAB). The MAB is a task organization that may be formed from 2/9th to 5/9th of the division/wing team. The ground combat element will normally equate to a regimental landing team and the aviation combat element is normally a provisional Marine aircraft group.

Marine amphibious force (MAF). The MAF may be formed with many variations in task organization structure, ranging in size from 5/9th division/wing team to several divisions and aircraft wings, together with an appropriate combat service support organization.

Marine amphibious unit (MAU). The MAU is a task organization which is normally built around a battalion landing team and a composite squadron. The MAU normally employs about one-ninth of the combat resources of one Marine division/wing team.

Mark (Mk). Navy designation for model.

meaconing. A system of transmitting actual or simulated radio navigational signals for the purpose of confusing navigation.

MEZ. Missile engagement zone (friendly).

MIJI. Any military actions in the electromagnetic spectrum described by meaconing, intrusion, jamming, or interference.

mil. A unit of angular measurement which subtends one meter in length at a distance of 1,000 meters.

mission commander. A mission commander, who shall be a properly qualified naval aviator or naval flight officer, should be designated when separate aircraft formations, each led by its own formation leader, are required for a common support mission or whenever a formation of four or more aircraft must perform a multiple sortie mission. The mission commander shall direct a coordinated plan of action and shall be responsible for the effectiveness of the mission. Helicopter mission commanders shall be qualified as HAC in model and should possess a minimum of 750 total flight hours. The mission commander may be, but is not limited to being, one of the formation flight leaders. The status of each member of the flight(s) shall be understood prior to flight.

mission, enemy, terrain and weather, troops (METT). Factors to be considered in estimating the situation during the planning of a military operation.

mission precedence. A designation assigned to a mission to indicate its priority or urgency of accomplishment. Precedence is not to be interpreted as a waiver for safe operating procedures contained in applicable NATOPS instructions unless explicitly specified by higher authority.

— **emergency mission.** Mission involves safety of U.S. or other friendly lives or requires immediate transport of vital supplies or equipment or urgently required resupply ammunition or medical supplies.

— **mandatory mission.** Emergency in nature and involves possible loss of human life or national prestige to the extent that normally unacceptable risks will be taken in its accomplishment.

— **priority medevac.** Evacuation of seriously wounded, injured, or ill personnel who require early hospitalization but whose immediate evacuation is not a matter of life or death.

— **priority mission.** Tactical movement of personnel or equipment whose excessive delay would jeopardize successful mission accomplishment. It includes logistic operations where delays would result in excessive material loss through spoilage or seizure by the enemy.

— **routine medevac.** Evacuation of deceased personnel or of a patient with a minor illness or a patient requiring transfer between medical facilities for further treatment.

— **routine mission.** Administrative or tactical support of personnel or equipment, where time is not a critical factor and delay will not endanger lives or loss of material.

— **urgent medevac.** Evacuation of critically wounded, injured or ill personnel who require early hospitalization but whose immediate evacuation is a matter of life or death.

N

nap-of-the-Earth flight. Flight as close to the Earth's surface as vegetation of obstacles will permit, while generally following the contours of the Earth.

Airspeed and altitude are varied as influenced by the terrain, weather, and enemy situation.

NVG. Night vision goggles.

O

optical countermeasures. Application of ECM in the visible light portion of the electromagnetic spectrum. Actions taken to prevent an enemy's effective use of the visible spectrum.

overshoot. A turn in which the radius of turn is larger than desired, resulting in lateral separation from the desired position.

P

P_a. Probability of acquisition.

passive homing guidance. A system of homing guidance wherein the receiver in the missile utilizes radiation from the target.

P_d. Probability of detection.

penetration control point (PCP). Penetration control point is the point where helicopter waves penetrate a hostile coastline.

penetration point. A point used for egress/ingress of friendly air defenses.

permissive threat. The threat, although sophisticated for short periods of time, is predominantly at a level which permits combat operations and support to proceed along traditional lines without prohibitive interference. Associated tactics and techniques will not normally require extraordinary measures for preplanned or immediate support.

R

R_{max}. Maximum firing range.

R_{mid}. Center of firing envelope.

R_{min}. Minimum firing range.

raspberry. A ship-to-shore HF radio net. Used for flight following and administrative traffic concerning aircraft.

reflectance. This is the relationship between illumination reaching a surface and the resulting luminance. A perfectly diffusing and reflecting surface would be the one that absorbs no light and scatters the illumination in the manner of a perfectly flat surface. Such a surface would have a reflectance of 100 percent. If illuminated by 1 ft-c, it would have a luminance of 1 foot-Lambert (ft-L) from all viewing angles. In actual practice, the maximum reflectance achievable for a nearly perfect diffusing surface is about 75 percent.

rules of engagement (ROE). Directives issued by competent military authority which delineate the circumstances and limitations under which United States forces will initiate and/or continue combat engagement with other forces encountered.

S

salvo. A group of several bombs or rocket missiles which were released or launched simultaneously (with no intentional spacing in range).

SAM. Surface-to-air missile.

scheduled waves. Formations of landing craft, amphibious vehicles, landing ships, or helicopters carrying the assault units of the landing force whose time and place of landing are predetermined.

secure area. An area that has not received hostile fire for 72 hours and in which helicopters will most likely not be subject to fire during the approach, landing, takeoff, or departure phase of operation.

semiactive homing guidance. A system of homing guidance wherein the receiver in the missile utilizes radiations from the target which has been illuminated by an outside source.

short-range air defense (SHORAD). SHORAD of local areas or point targets is provided by quick-reacting weapons designed to counter the immediate low-altitude air threat that penetrates LOMAD coverage. Examples of typical SHORAD threat systems would be SA-8 and SA-9 and the U.S. Chaparral. Normally, they will be organic to division or lower echelons, and will be deployed in large numbers in the vicinity of the FEBA. All such systems are highly mobile and will frequently be used in the protection or armor columns and reserves.

sight angle. The angle between the zero mil sight line and the line of sight.

slant range. The distance between a weapon and the target at the instant of firing or release.

sophisticated threat. The threat posed by a hostile force which would entail the integrated massing of heavy combat power to include electronic warfare, surface-to-air weapons, and other anticommand and control measures so as to seriously degrade the capability to provide the necessary support to Marine Corps forces.

special patrol insertion/extraction (SPIE) system. A system for rapidly extracting reconnaissance patrols from areas which do not permit helicopter landing.

standardization agreement (STANAG). The record of an agreement among several or all the NATO member nations to adopt like or similar military equipment, ammunition, supplies and stores, and operational logisti and administrative procedure.

supporting arms coordination center (SACC). A single location on board an amphibious command ship in which all communication facilities incident to the coordination of fire support of the artillery, air, and naval gunfire are centralized. This is the naval counterpart to the fire support coordination center utilized by the landing force.

suppressive fire. The type of heavy volume fire delivered for area neutralization in order to provide protection for transport helicopters during the approach, landing, or departure phase of operation.

suspension unit universal (SUU). A device for carrying and ejecting a large number of bomblets or projectiles from an aircraft.

T

tactical air coordinator airborne (TAC(A)). TAC(A) is an experienced aviator in the area of operations in a helicopter or fixed-wing aircraft. His primary responsibility is to coordinate and direct the activities of aircraft assigned to him and to report to the appropriate ground and air control agencies in his area of responsibility. The coordination function may involve the handling of a variety of types and numbers of aircraft or integrating air activity between helicopters and conventional aircraft as in a helicopter assault, landing zone preparation, resupply, or other air activity. A secondary mission of the TAC(A) is the detection and destruction of enemy targets through close or deep air support. The TAC(A) should also have a thorough understanding of supporting arms coordination and artillery/naval gunfire spotting procedures. In the performance of his mission, the TAC(A) is an extension of the Direct Air Support Center (DASC).

tactical air command center. The principal United States Marine Corps air operation installation from which aircraft and air warning functions of tactical air operations are directed. It is the senior agency of the Marine Corps air command and control system from which the Marine Corps tactical air commander can direct and control tactical air operations and coordinate such air operations with other services. (The naval counterpart is the Tactical Air Control Center.)

tactical air control party (TACP). A subordinate operational component of a tactical air control system designed to provide air liaison to land forces and for the control of aircraft.

tactical air control squadron (TACRON). An administrative and tactical component of the naval tactical air control group which provides the control mechanism or the ship-based tactical air direction center or the ship-based tactical air control center.

tactical air direction center (TADC). An air operations installation under the overall control of the tactical air control center (afloat) tactical air command center, from which aircraft and air warning service functions of tactical air operations in an area of responsibility are directed.

tactical air operations center (TAOC). A subordinate operational component of the Marine air command and control system designed for direction and control of all en route air traffic and air defense operations, to include manned interceptors and surface-to-air weapons, in an assigned sector. It is under the operational control of the tactical air command center.

terrain flying (TERF). Terrain flying is the tactic of employing aircraft in such a manner as to utilize the terrain, vegetation, and manmade objects to enhance survivability by degrading the enemy's ability to visually, optically, or electronically detect or locate the aircraft. (See low level flight, contour flight, and nap-of-the-Earth flight).

tow. Tube-launched, optically tracked, wire command-link.

trajectory drop. The effect of gravity and drag on the weapon after release. Trajectory drop is the angle mils between the line of sight to the impact point and the aircraft flightpath for bombs; for rockets the launcher line is used.

U

TSU. Telescopic sight unit.

ultrahigh frequency. A frequency of 300 to 1000 MHz.

very high frequency. A frequency of 30 to 300 MHz.

very low frequency. A frequency below 30 kHz.

VID. Visual identification.

vulnerability. *Liable to attack* or *open to being damaged/destroyed.* In tactical flight operations, the degree of vulnerability is the result of the level of hostilities in the operation area and duration of exposure. These two factors are influenced in varying degrees by aircraft capabilities, enemy opposition, helicopter force, pilot proficiency, and weather.

WERM. Acronym for formula used to determine range of a known size target using a mil sight. Range equals width/length of target (as seen) in meters times 1,000 divided by the number of mils the target covers in the mil sight.

Z

zip lip. A condition which may be prescribed during day/VFR operations requiring radio transmission. Only transmissions requisite to safety of flights are permitted.

ZIPPO team. A team, consisting of the helicopterborne unit commander, the helicopter element commander, and key staff members, who jointly inspect, prepare, and plan helicopterborne operations in which their units are participating.

Zippo brief. Zone inspection, Planning, Preparation and Operation Evaluation Brief is a face to face conference of the Zippo Team members. This brief will discuss all pertinent items to include aircraft performance in relation to anticipated tactic, threat, and load factors.

PREFACE

SCOPE

The AH-1 Tactical Manual, prepared under the direction of Commander, Operational Test and Evaluation Force and approved by the Chief of Naval Operations, contains the latest information regarding the tactical employment of the AH-1 helicopter and its various combat missions. Information contained in this manual has been derived from many sources to provide one main source for procedures, techniques, and suggested data to enable the pilot and copilot to employ the helicopter and its weapons system most effectively in combat. The NATOPS Flight Manual standardizes ground and flight training procedures and contains the information to thoroughly acquaint the pilot and copilot with the aircraft. Information in this manual is primarily oriented to tactical employment of the helicopter which presupposes a thorough knowledge of the NATOPS Flight Manual. A description of the Aircraft Tactical Manual program is contained in NWP 0.

The AH-1 Tactical Manual is intended to be used in conjunction with NWP 55-9-ASH, Assault Helicopter Tactical Manual, Volume I (U), Volume II (S), and Pocket Guide (U). The ASH manual contains the latest information regarding the tactical employment of assault helicopters and their various combat missions. A thorough working knowledge of both this tactical manual and the ASH Tactical Manual is required for the successful completion of all assigned tasks.

For expanded threat data, also refer to NWP 12-1, Tactical Air Analysis (U); NWP 12-7-2, Recognition Guide to Aircraft (U); and NWP 12-8, Threat Intelligence Summary — Naval Air Forces (S).

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Recommended changes to this manual may be submitted by anyone in accordance with NWP 0. Submit Routine Changes recommendations to the Model Manager on OPNAV Form 3500-22. (See the following sample form.) Address routine changes to ATTACK HELICOPTER TACTICAL MANUAL

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Recommendation (be specific)

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A. Manual identification (NWP NO., NAVAIR NO., REVISION, DATE, ETC)

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The Interim Change Summary is provided for the purpose of maintaining a complete record of all Interim Changes issued to the manual. Each time the manual is changed or revised, the Interim Change Summary will be formally updated to indicate disposition and/or incorporation of previously issued Interim Changes. When a regular change or revision is received, the Interim Change Summary should be checked to ascertain that all outstanding Interim Changes have been formally incorporated or cancelled. Those changes that were not incorporated should be noted as applicable. The Tactical Publications Status Report published monthly by the Navy Tactical Support Activity contains a summary of latest changes to all tactical manuals.

WARNINGS, CAUTIONS AND NOTES

The following definitions apply to "WARNINGS," "CAUTIONS," and "NOTES" found through the manual.

WARNING

An operating procedure, practice, or condition, etc., which may result in injury or death if not carefully observed or followed.

CAUTION

An operating procedure, practice, or condition, etc., which may result in damage to equipment if not carefully observed or followed.

Note

An operating procedure, practice, or condition, etc., which is essential to emphasize.

WORDING

The concept of word usage and intended meaning which has been adhered to in preparing this Manual is as follows:

"Shall" has been used only when application of a procedure is manadatory.

"Should" has been used only when application of a procedure is recommended.

"May" and "need not" have been used only when application of a procedure is optional.

"Will" has been used only to indicate futurity, never to indicate any degree of requirement for application of a procedure.

CHANGE SYMBOLS

Revised text is indicated by a black vertical line in either margin of the page, like the one printed next to this paragraph. The change symbol shows where there has been a change. The change may be material added or information restated.

DESIGNATOR SYMBOLS

Designator symbols are used in conjunction with the illustrations in Chapter 1 to show effectivity of the material. The following symbols are used:

J AH-1J

T AH-1T

PART I

Air-to-Ground Warfare

Chapter 1 — Air-to-Ground Warfare

Chapter 2 — Weapons Delivery

Chapter 3 — Weapons Description

Chapter 4 — Weapon System Employment

CHAPTER 1

Air-to-Ground Warfare

1.1 HELICOPTER WEAPON SYSTEM

This chapter describes the components of the weapon system of direct concern to the aircrew in the delivery of weapons.

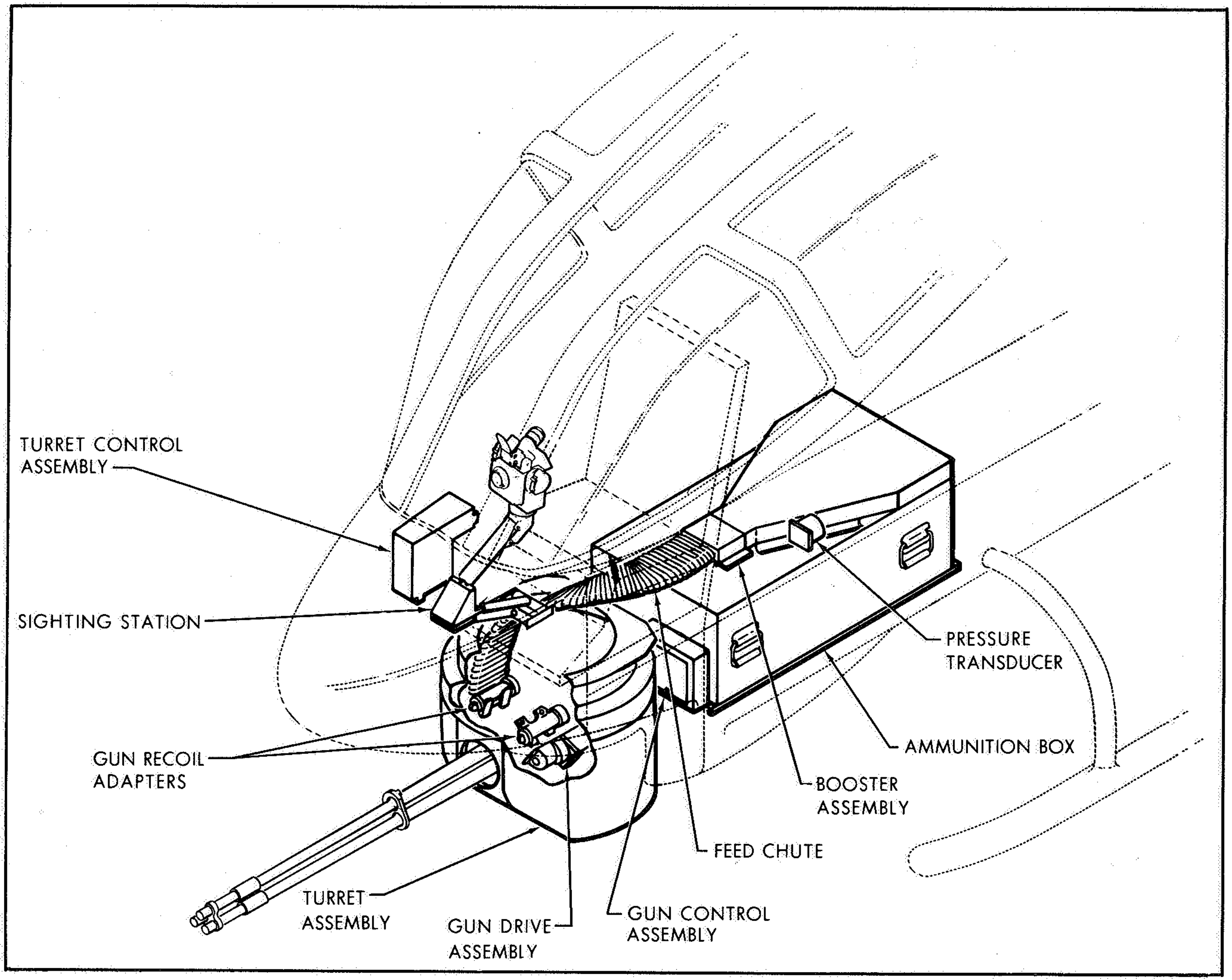
1.2 AH-1J WEAPON SYSTEM

The components of the weapon system of direct concern to the aircrew include emergency jettison system, A/A49E-2 or A/A49E-7(V)l/turret system, wing stores armament system, and smoke grenade dispensing sytem.

1.2.1 A/A49E-2 or A/A49E-7(V)1/20-mm Turret System. The A/A49E-2 or A/A49E-7(V)l/turret system provides for sighting, provisioning, and firing of the M197, 20-mm automatic gun. The system consists of a turret assembly, a turret control assembly, gunner/copilot and pilot controls located on their respective armament control panels, and the gunner/copilot sighting station. Figure 1-1 shows the location of turret system components in the helicopter. The turret system is electrically operated at 28 vdc and 115 vac, 400-Hz power from the helicopter electrical system. Application of power to energize the turret system is normally controlled by circuit breaker switches on the pilot ac circuit breaker panel. Direct application of emergency 28-vdc power is made to an auxiliary turret drive circuit in the turret assembly. This auxiliary drive circuit provides emergency stow control, ensuring that the turret will position the gun in a safe position for landing the helicopter whenever normal power is removed for any reason. A PILOT OVERRIDE switch is provided on the gunner/copilot armament control panel to allow the gunner/copilot to bypass pilot-control operation of the turret system if the pilot is disabled (Figure 1-2).

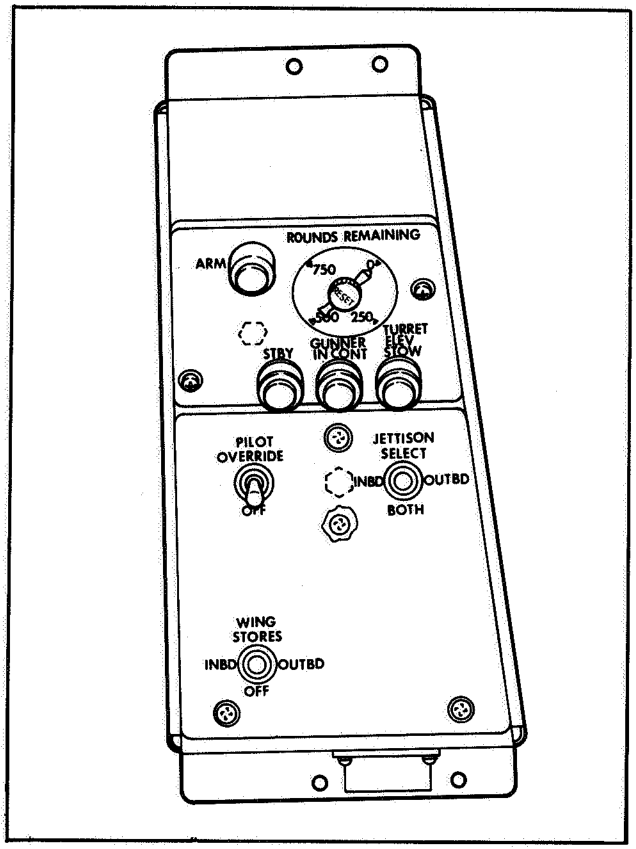
1.2.1.1 M197 20-mm Gun. The 20-mm automatic gun is comprised of three major assemblies: the barrels, the housing assembly, and the rotor assembly. As the rotor turns in a counterclockwise direction (looking from the breech), interaction between the rotor and housing (by means of cams and gearing) causes the various actions to take place. There are six actions or operations: feed, chamber, lock and fire, unlock, extract, and eject.

1.2.1.1.1 Operational Description. The turret assembly, which is chin mounted on the helicopter, provides a mounting for the gun. Electrical circuits in the sighting station, turret control assembly, and the turret provide remote control for the azimuth and elevation drive systems in the turret. The azimuth drive system points the gun over an azimuth range of 110° either side of 0° azimuth. The gun may be lowered a maximum of 50° below 0° elevation. The amount of elevation of the gun above the horizontal is made to vary with the azimuth position of the gun. The variable upper elevation limits ensure sufficient clearance of the helicopter rotor blades during firing of the gun. Mechanical stops in the turret prevent pointing of the gun beyond the azimuth and elevation limits. Electrical limit switches remove power to the turret drive systems just before the turret reaches the mechanical stops. The limit switches also disable circuits in the gun control assembly to prevent firing of the gun during the time the turret is at a positional limit and cause the reticle in the gunner/copilot sight to flash. The gun control assembly electrically controls operation and firing of the gun and operation of the ammunition feed system. If the turret is positioned within the operational limits and within 5.5° of the azimuth and elevation command signals, the gun control



J Figure 1-1. 20-mm Turret System (Typical)

assembly applies power to the gun drive and ammunition feed systems upon receipt of a trigger command signal. The gun control assembly also supplies firing voltage and applies it to the gun at the time gun drive power is applied. The gun drive assembly rotates the gun barrels at a firing rate of approximately 750 shots per minute. The power applied to the ammunition feed system operates the booster assembly located on the ammunition box and energizes a declutching solenoid on the gun feeder. The booster assembly and gun feeder provide a flow of belted 20-mm ammunition from the ammunition box to the gun. The capacity of the ammunition box is 750 rounds of continuously belted 20-mm ammunition. However, to prevent fouling, loads of no more than 700 rounds should be used. The gun is



209075-91

J Figure 1-2. Gunner Armament Panel

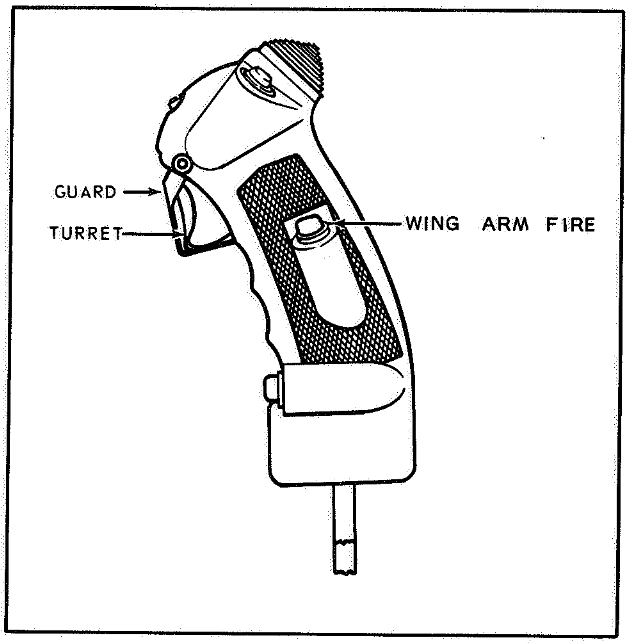
fired for the duration of a trigger command plus a gun clearing cycle, or in limited bursts of 16 ± 4 shots per burst. A BURST LIMIT switch on the sighting station, when actuated, allows the gun control assembly to terminate each trigger command automatically after sufficient time has elapsed to fire 16 ± 4 shots. The gun control will also terminate a firing command any time the turret reaches an up, down, right, or left limit and whenever the turret position disagrees to azimuth or elevation more than 5.5° from the position command signal. The flow of ammunition to the gun is stopped immediately whenever a trigger command is terminated. Unless trigger command is terminated by a position error, time delay circuits in the gun control assembly continue gun drive power and firing voltage long enough for the gun to fire the ammunition remaining in the gun. Should trigger command be terminated by a position error in excess of 5.5°, firing voltage is also terminated simultaneously. The gun drive is continued, however, to clear live ammunition from the gun. The turret system has three modes of operation: pilot control, gunner/copilot control, and pilot override. During pilot control operation, the gun remains in a fixed position at 0° azimuth and elevation. The pilot fires the gun with a guarded trigger on his cyclic stick (Figure 1-3). The pilot reflex sight assembly (Figure 1-4) contains a reticle which is illuminated by a dual-filament lamp. During gunner/copilot control, the gun is pointed and fired by means of sighting station (Figure 1-5) which has a sight assembly mounted on a flexible pedestal. On Bu No 159214 and subsequent, the sight provides a seven-power magnification. The pedestal allows easy stowing of the sighting station when not in use and movement of the sight assembly when in use. Two handgrips contain a spring-loaded action switch and a spring-loaded trigger switch. Depression of either action switch energizes the turret positioning circuits in the turret assembly. The copilot fires the gun by pressing either trigger switch on the handgrips. Operation of the PILOT OVERRIDE switch is fully covered in the following paragraph.

1.2.1.2 Turret Controls. The following controls (Figure 1-6) are provided to aim and fire the turret.

1.2.1.2.1 MASTER ARM Switch. The MASTER ARM switch electrically controls the application of power to the turret sytem.

Note

Power for the MASTER Arm switch originates from the ROCKET POWER circuit breaker which must be closed for use of any



209900-153A

J Figure 1-3. Pilot/Gunner Cyclic Grip

weapon system. Refer to Wing Stores Armament System for additional functions of the MASTER ARM switch.

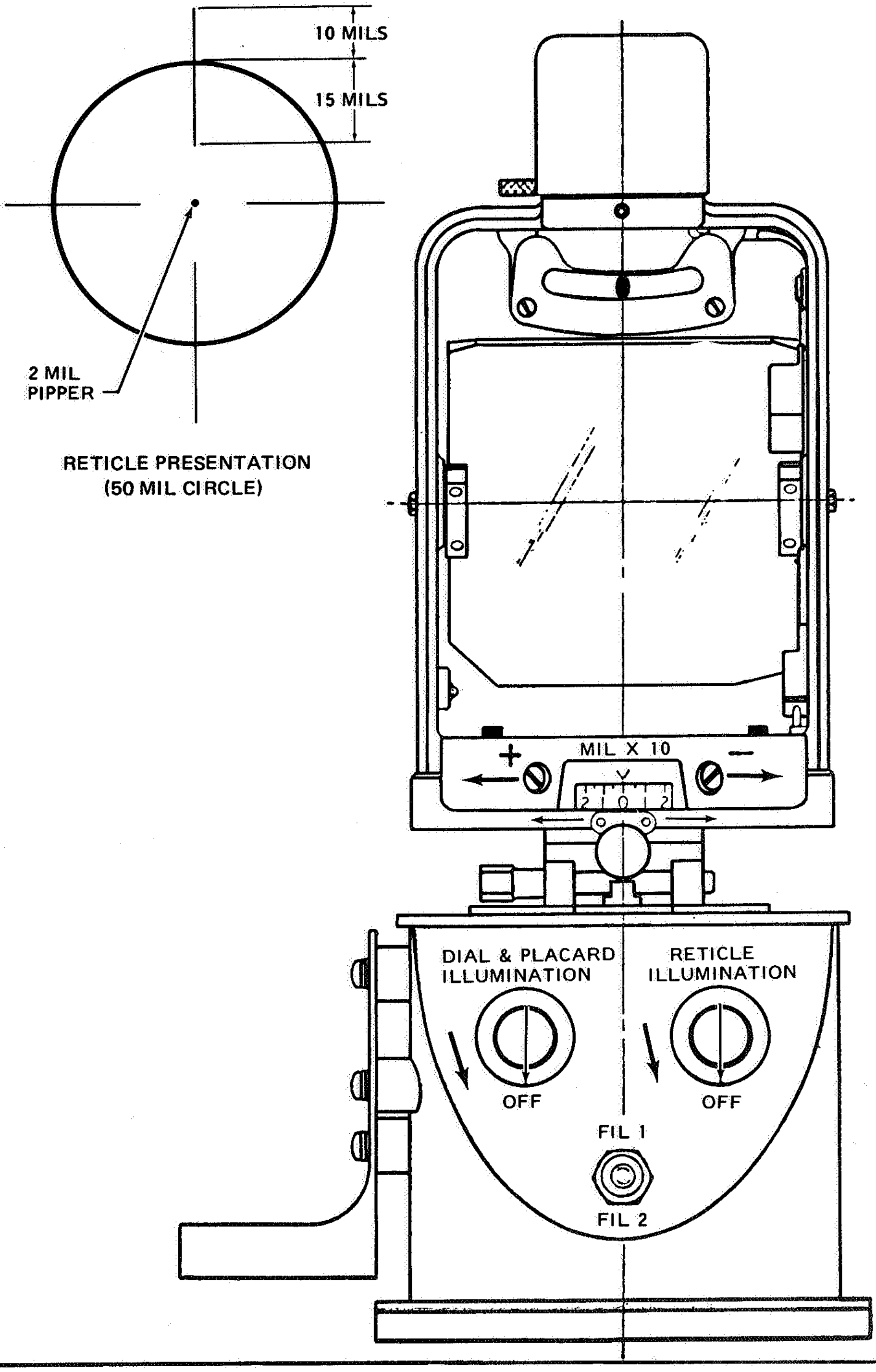
1. SAFE position removes power from the turret system, except for the ammo loading switch and emergency 28 vdc, which is applied directly to the emergency stow control unit in the turret.

2. STBY position activates the turret positioning circuits and illuminates the STBY indicator lights on the pilot and gunner/copilot armament control panels. Gun firing circuits are not activated.

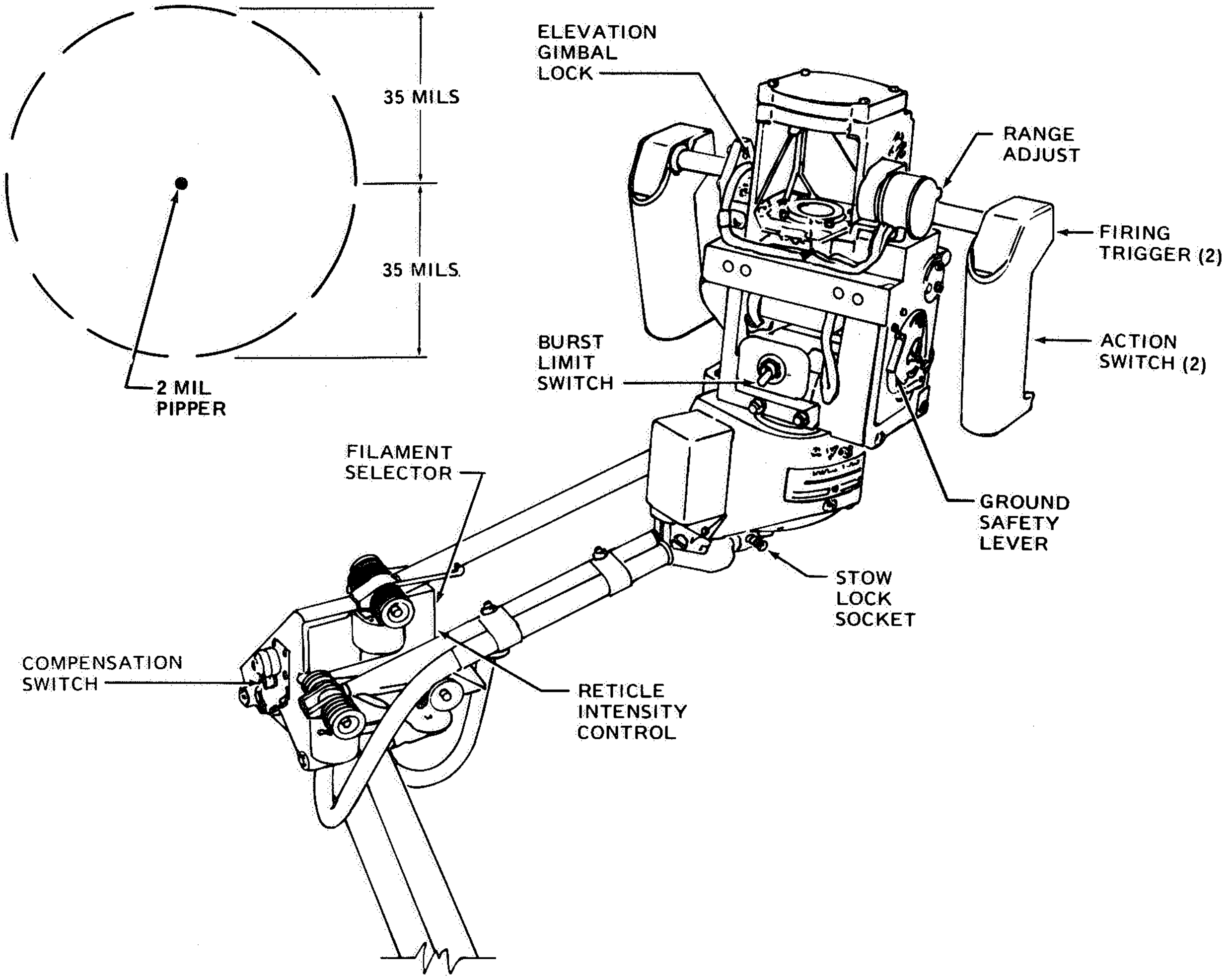
3. ARM position provides gun firing power to the turret systems and illuminates both the STBY and ARM indicator lights on the pilot and gunner/copilot armament control panels.

1.2.1.2.2 TURRET CONTROL Switch. The TURRET CONTROL switch is located above the weapons registration switches on the pilot armament control panel. The switch establishes electrical control of the mode of operation of the turret system. With the switch in PILOT position, the turret automatically positions the gun to 0° azimuth and elevation. The pilot then fires the gun as a fixed-position weapon by pulling the guarded trigger on his cyclic stick. The COPILOT position of the switch energizes the sighting station circuits and illuminates the GUNNER IN CONT indicator light on the gunner/copilot armament control panel (Figure 1-2). The gunner/copilot then uses the sighting station to position the turret and fire the gun. This system also features a trigger-lockout capability which enables the pilot to take turret position control away from the gunner/copilot at any time, primarily for the purpose of releasing forward-firing stores (rockets, gun pod, etc.) from the wing stations. Pulling of the pilot trigger to the first detent or beyond automatically brings the gun to 0° azimuth and elevation and disables the gunner/copilot's gun firing circuit. The pilot may then release forward-firing stores by pressing the WING ARM FIRE button, while maintaining trigger pressure to at least the first detent. The gun will not fire if the pilot trigger is fully depressed in this mode. Any time the pilot releases trigger pressure, the gun will automatically reposition itself to correspond with the position of the gunner/copilot sighting station after a delay of one-half second. The gunner/copilot sight reticle flashes whenever his gun firing circuit has been disabled by depressing the pilot trigger with the TURRET CONTROL switch in COPILOT position.

1.2.1.2.3 PILOT OVERRIDE Switch. The PILOT OVERRIDE switch is located on the gunner/copilot armament panel (Figure 1-2). When set to PILOT OVERRIDE position the switch electrically bypasses the MASTER ARM switch and all other armament switches on the pilot armament control panel. The pilot armament system is activated, with the

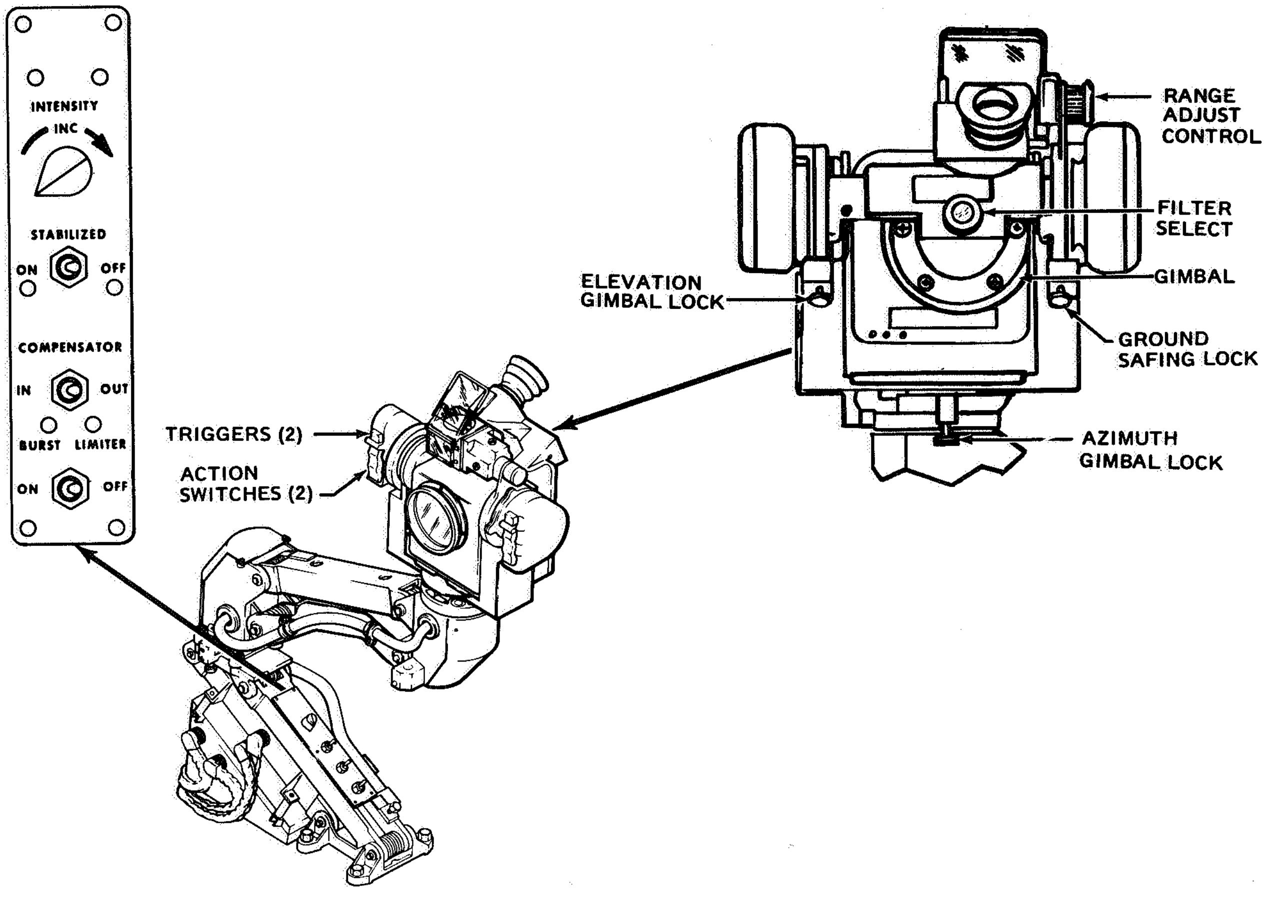


J Figure 1-4. Pilot Reflex Sight



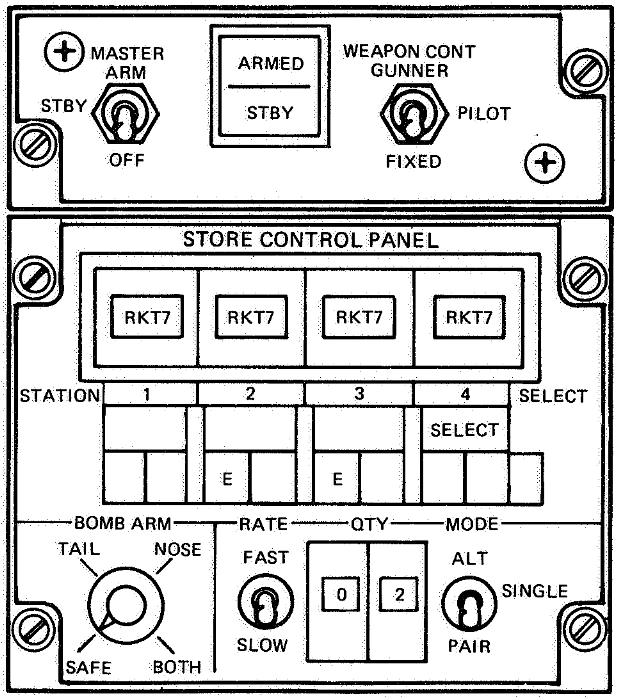
(Helicopter BuNo 157757 through 159213)

J Figure 1-5. Gunner Pantographic Sight (Sheet 1 of 2)



(Helicopter BuNo 159214 and Sub)

J Figure 1-5. Gunner Pantographic Sight (Sheet 2 of 2)



J Figure 1-6. Pilot Armament Panel

exception of smoke grenade control, and the turret which positions the gun at 0° azimuth and elevation. The sighting station is disabled during pilot override operation. The gunner/copilot fires the gun as a fixed-position weapon by pressing the guarded trigger on his cyclic stick (Figure 1-3) and releases wing stores by pressing the WING ARM FIRE button. When set to the OFF position, the PILOT OVERRIDE switch allows normal control of the helicopter armament system by the MASTER ARM switch and all other armament switches on the pilot armament control panel.

1.2.1.2.4 Action Switches. Two action switches are located on the sighting station handgrips (Figure 1-5). Depression of either action switch in gunner/copilot control operation of the turret system energizes the turret positioning circuits and causes the gun to point at the target selected by the sight and to follow any movement of the sight. When the action switches are released, the turret automatically positions the gun in the upper stow position, which is 11° above the horizontal and 0° azimuth.

1.2.1.2.5 Trigger Switches. Two trigger switches are located on the sighting station handgrips (Figure 1-5). Depression of either spring-loaded trigger provides an electrical command signal to the gun control assembly, provided the gunner/copilot is in control and one of the action switches is depressed. Releasing both trigger switches removes the command signal. The gun control assembly prevents firing of the gun if the turret is positioned at any one of the four mechanical stops or if the sighting station is positioned faster than the turret is capable of following.

1.2.1.2.6 BURST LIMITER Switch. The BURST LIMITER switch is located on the sighting station (Figure 1-5). When set to the ON position, the switch electrically limits the duration of trigger command signals to the time period required to fire 16 ± 4 rounds from the gun. The OFF position of the BURST LIMITER switch allows trigger command signal duration to be determined by the pilot or gunner/copilot.

1.2.1.2.7 Range Adjust Control. The range adjust control is located on the sighting station (Figure 1-5). Rotation of the control effects range compensation into the turret positioning circuits. The control dial is calibrated in meters and allows the gunner/copilot to set the estimated range of targets up to a maximum range of 3,000 meters. Clockwise rotation of the control dial to estimated range increases the range signal and results in an increase in elevation of the gun.

1.2.1.2.8 Compensation Switch. The COMP switch is located on the sighting station (Figure 1-5). When set to IN position, the switch transmits an electrical airspeed signal to the turret positioning circuits. The OUT position of the switch removes the airspeed compensation signal.

1.2.1.2.9 Sight Reticle INTENSITY Control. The sight reticle INTENSITY control is located on the sighting station (Figure 1-5). Clockwise rotation of the control knob increases illumination intensity of the reticle lamp, and counterclockwise rotation reduces the intensity. Rotation of the control knob fully counterclockwise turns the reticle lamp off.

1.2.1.2.10 Filament Selector Switch. The FIL SEL switch is located on the sighting station (Figure 1-5). The switch permits selection of either filament of the dual-filament reticle lamp.

1.2.1.2.11 Azimuth Gimbal Lock. The azimuth gimbal lock is located on the sighting station (Figure 1-5). When pressed, the gimbal lock engages a slot in the azimuth housing and mechanically holds the sight at the 0° azimuth position. When the lock is disengaged, the sight is free to rotate throughout the turret azimuth range.

1.2.1.2.1.12 Elevation Gimbal Lock. The elevation gimbal lock is located on the sighting station (Figure 1-5). The gimbal lock, when depressed, engages a slot in the elevation gimbal bracket which mechanically holds the sight at the 0° elevation positon. When the lock is disengaged, the sight is free to rotate over the entire elevation range.

1.2.1.2.13 Stabilization Switch. On helicopters BUNO 159214 and subsequent, the sight (Figure 1-5, Sheet 2) has a switch labeled STABILIZED/ON/OFF. These sights are gyroscopically stabilized with the switch in the ON position.

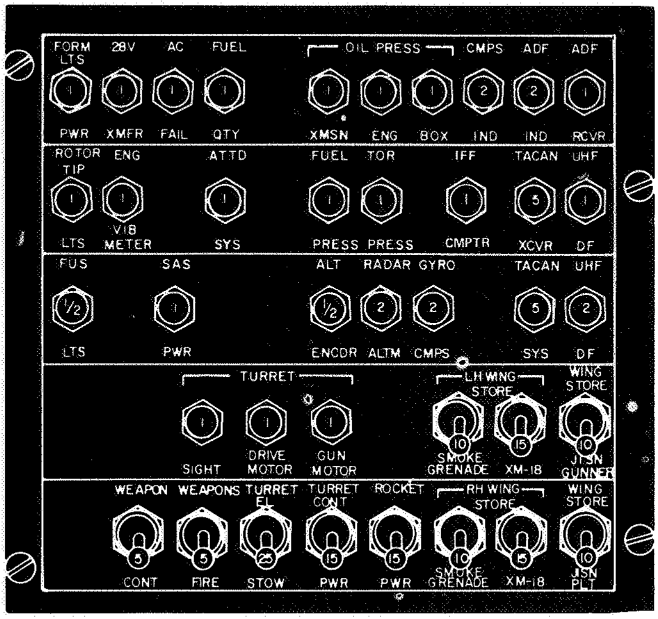
1.2.1.2.14 Ground Safety Lever. The ground safety lever is located on the sighting station (Figure 1-5). When raised to the GROUND POSITION, the lever positions a mechanical stop to prevent lowering of the sight more than 15° below the 0° elevation position. This prevents driving the gun barrels into the ground when the helicopter is on the ground. When lowered to the FLIGHT POSITION, the lever positions a mechanical stop to allow movement of the sight over the entire elevation range of the sight gimbal.

1.2.1.2.15 Turret Elevation Stow Indicator Lights. The TURRET ELEV STOW indicator lights are located on the gunner/copilot armament panel (Figure 1-2) and in the upper right-hand corner of the pilot instrument panel. The indicator lights illuminate when the gun has been positioned to the upper stow position and the MASTER ARM switch is in the SAFE position.

1.2.1.2.16 ROUNDS REMAINING Indicator. The ROUNDS REMAINING indicator is located on the gunner/copilot armament panel (Figure 1-2). The indicator pointer is manually positioned at 750 when the turret system is fully loaded with ammunition. Electrical pulses reduce the indication of rounds remaining as ammunition is expended from the system. The indicator cannot be considered accurate for the last 50 rounds because the booster continues to turn after the last round has passed through the booster.

1.2.1.3 Pilot AC and Armament Circuit Breaker Panel. The ac circuit breaker panel is located in the pilot left console (Figure 1-7). The armament circuit breakers are the toggle push-pull type.

1.2.2 Wing Stores Armament System. The armament management system (AMS) enables the pilot to program the automatic release of stores from four helicopter wing stations in the quantity, mode, and drop interval selected, and the gunner/copilot to selectively release in a PILOT OVERRIDE condition, inboard or outboard pairs only. The AMS permits selective weapon release by the pilot. It incorporates safety features which require matching of the selected station and the selected type of stores with the actual type of stores registered for the station. The AMS provides the capability for



J Figure 1-7. AC and Armament Circuit Breaker Panel

in-flight arming of droppable stores, thus allowing emergency jettison of unarmed stores over friendly areas. In addition, the AMS provides protection from selection of incorrect release modes for specific weapon stores; for example, preventing the use of salvo mode with downward-ejected stores and by automatically providing a time delay between jettison of adjacent stores to prevent their colliding on release.

The AMS consists of a programmer, controller, pilot armament panel, left and right wing junction boxes, the WING ARM FIRE button on the pilot cyclic stick, the WING STORES switch on the gunner/copilot armament panel, and the WING ARM FIRE button on the gunner/copilot cyclic stick.

1.2.2.1 Wing Stores Controls. The following controls are provided to arm and release weapons from the wing stores racks.

1.2.2.1.1 Programmer. The programmer is located behind the aft panel of the ammunition compartment. The programmer integrates commands from the pilot WING ARM FIRE button, the controller, and the armament control panel with stores information from the weapons stations to produce the required outputs.

1.2.2.1.2 Controller. The controller (Figure 1-6) is mounted in the cockpit above the pilot armament control panel. The controller contains the following front panel controls: a quantity (QTY) select (SEL) switch, a power on (PWR ON) indicating lamp, a DROP INTVL selector, a multiplier switch (MULT SW), and a MODE SELECT switch.

CAUTION

When QTY SEL switch is in the OFF position, stores should not be selected or simultaneously released from both stations on either wing.

Note

AWE-1 use is not recommended for use with rocket launchers currently in the Navy inventory.

a. QTY SEL Switch. The QTY SEL switch performs two functions:

1. OFF — by-passes the automatic control features of the controller and programmer.

2. ON — when set to any of the quantity positions, provides operating power to the programmer and controller for both STEP and RIPPLE modes of operation.

b. PWR ON. The PWR ON indicating lamp is illuminated when 28 vdc and 115 vac are supplied to the programmer. The light will not be illuminated if either of these voltages is removed.

c. DROP INTVL. In conjunction with the multiplier switch (MULT SW), the DROP INTVL switch determines the time interval in milliseconds at which release pulses will be delivered in any RIPPLE mode.

d. MULT SW. Selects multiplication factors of 1 or 10 by which the indicated drop interval increments are multiplied.

1. X1 selects a drop interval range of 20 to 200 milliseconds.

2. X10 selects a drop interval range of 200 to 2,000 milliseconds.

WARNING

Check appropriate ordnance section for minimum intervalometer time for SALVO MODE.

e. MODE SELECT. Selects STEP or RIPPLE modes of release. The release priority logic dictates that left station has priority over right station and outboard stations have priority over inboard stations. SALVO is the only exception, having no station priorities. Priority logic may be overridden by the pilot at any time by deselecting stations. Upon reselecting these stations, the priority logic returns to its normal pattern. Station transfer from outboard to inboard occurs when the stores on outboard stations are depleted.

Note

All mode functions in the subsequent discussion require weapons registration, station select, and ARM select switches to be in agreement.

(1) STEP. STEP modes utilize pilot-initiated release pulses for manual release of stores.

1. STEP SINGL — each time the WING ARM FIRE button is pressed, one fire pulse is applied to a selected weapon station. These pulses are applied in a left-right, outboard to inboard priority.

2. STEP PAIRS — each time the WING ARM FIRE button is pressed, one fire pulse is applied simultaneously to a selected pair of weapon stations.

3. STEP SALVO — each time the WING ARM FIRE button is pressed, one fire pulse is applied simultaneously to all selected weapons stations.

(2) RIPPLE. RIPPLE modes utilize preselected quantities and time intervals on the QTY SEL and DROP INTVL controls for automatic release of stores. The ripple sequence is initiated by pressing the pilot WING ARM FIRE button and will terminate when the quantity sequence is satisfied, when the stores have been depleted, or when the WING ARM FIRE button is released.

1. RIPPLE SINGL — pressing the WING ARM FIRE button causes a sequence of release pulses to be applied to each selected weapons station in turn.
2. RIPPLE PAIRS — pressing the WING ARM FIRE button causes a series of release pulses to be applied simultaneously to a selected pair of weapons stations.
3. RIPPLE SALVO — pressing the WING ARM FIRE button causes a series of release pulses to be applied simultaneously to all selected weapons stations.

1.2.3 Pilot Armament Panel. The pilot armament panel (Figure 1-6), located at lower center of the pilot instrument panel, is the system by which all helicopter armament is energized with the exception of pilot override and jettison modes. It contains the following controls and indicators: a TURRET CONTROL switch, four thumbwheel weapon registration switches, four STATION SELECT switches, a BOMB ARM switch, an ARM SELECT switch, a MASTER ARM switch, and two arming condition indicator lamps (an amber caution indicator and a red warning indicator).

1.2.3.1 Turret Control Switch. The TURRET CONTROL switch is a two-position toggle switch.

PILOT: the GTU-1A turret assumes the lower stow position, and the pilot gains control of the turret weapon.

COPLT: the gunner/copilot has control of the turret weapon.

1.2.3.2 Station Weapon Registration Switches. Four identical thumbwheel registration switches are mounted in the center of the panel, one for each wing station. The switch is a ten-position thumbwheel adjustable switch with a display window. The switch for each station (1 through 4) is manually set to register the type of weapon stores installed at the specific station. Each switch can be set to the following displays:

1. RKT 19 — nineteen-tube rocket launcher
2. RKT 7 — seven-tube rocket launcher
3. RKT 4 — four-tube rocket launcher
4. FLARE — flare dispenser, SUU-44
5. TNG BB — training bomb
6. BOMB — bomb
7. GUN PD — gun pod
8. DISP — chemical/particle type dispenser
9. EMPTY — indicates no weapons.

1.2.3.3 STATION SELECT Switches. The four station select switches are identical two-position toggle switches which are mounted below the thumbwheel registration switches, with one switch for each wing station.

1. ON — the station select switches are numbered and oriented with the corresponding wing stations. The associated wing station will be ready to receive release or fire pulses for weapon/stores release.

2. OFF — associated wing stations will receive no release or fire pulses.

1.2.3.4 BOMB ARM Switch. The BOMB ARM (arming) switch is a four-position rotary switch which provides the capability of takeoff and flight with droppable stores (bombs) in the unarmed (safe) position and for selective arming of bombs in flight. The switch will become functional only when the ARM SELECT switch is set to MSBR or BB position.

1. SAFE — all arming solenoids deenergized.

2. TAIL — tail arming solenoids energized. Nose arming solenoids deenergized.

3. NOSE — nose arming solenoids energized. Tail arming solenoids deenergized.

4. BOTH — both nose and tail arming solenoids energized.

1.2.3.5 ARM SELECT Switch. The ARM SELECT switch is a six-position rotary switch which permits selection of general types of weapons stores to be released or fired from the wing stations. Specific weapons which fall into the general category selected on the ARM SELECT switch will be released when the corresponding station select switches are set to the ON position and the pilot initiates a release pulse.

1. SAFE — no release or fire pulses will be delivered to wing stores.

2. DISP (dispenser) — any selected station equipped with and registered to carry a dispenser (DISP) will receive a release pulse when a release signal is initiated.

3. MSBR (multiple stores bomb rack) — any selected station equipped with and registered to carry FLARE, or TNG BB, will receive a release pulse when a release signal is initiated. When a droppable store is selected, an interlock is engaged which will automatically provide the single release mode if a salvo release mode has been selected on the controller MODE SELECT switch.

4. RKTS (rockets) — any selected station equipped with and registered to carry RKT 4, RKT 7, or RKT 19 will receive a release pulse when a release signal is initiated. In the RKTS position, the minimum selectable drop interval (AWRS mode) is 80 ± 20 milliseconds.

5. BB (bomb) — a selected station equipped with and registered to carry bombs will receive a release pulse when a release signal is initiated. An interlock is engaged which will automatically provide the SINGLE release mode if a SALVO release mode has been selected on the controller MODE SELECT switch.

6. GUN PD (gun pod) — any selected station equipped with and registered to carry gun pods will receive a continuous firing signal when the WING ARM Fire button is pressed and held. When the ARM SELECT switch is set to the GUN PD position, power is removed from the controller (power on light not illuminated), the programmer is by-passed, and gun pod firing power is provided directly from the MASTER ARM circuit.

1.2.3.6 MASTER ARM Switch. The MASTER ARM switch is a three-position, positive lock toggle switch which electrically controls the application of power to the helicopter armament system with the exception of the jettison system and pilot override operation.

1. SAFE — removes power from the armament circuits and turret system, except for the turret ammo loading switch and the emergency stow control unit in the turret.

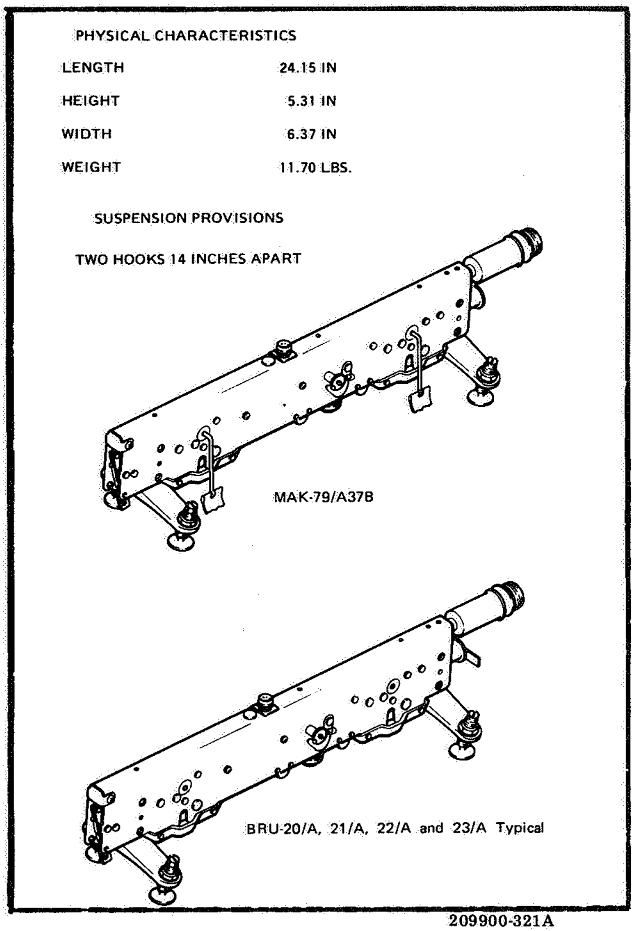
2. STBY — activates the turret positioning circuits and illuminates the STBY indicator lights on the pilot and gunner/copilot

armament control panels. Gun firing circuits are not activated; however, gun pod battery charging is provided. The smoke grenade dispenser system is activated and grenades can be dispensed.

3. ARM — provides power to all helicopter armament systems.

1.2.3.7 Wing Junction Box. Two identical wing junction boxes, which provide the interface between the armament control system and armament, are installed in the helicopter, one in each wing.

1.2.4 Wing Stations. Each wing has two hard point stations (Figure 1-8) on which various rocket launchers, dispenser, bomb racks, gun pods, and single bombs may be carried. Each station incorporates similar MAK-79 or BRU 20/A, 21/A, 22/A, 23/A ejector units with electrically primed explosive cartridges, which force-eject loaded stores. The inboard stations eject their respective stores at a 45° angle outboard to clear the skid landing gear and the outboard stations eject their respective stores vertically downward.



PHYSICAL CHARACTERISTICS

LENGTH	24.15 IN
HEIGHT	5.31 IN
WIDTH	6.37 IN
WEIGHT	11.70 LBS.

SUSPENSION PROVISIONS

TWO HOOKS 14 INCHES APART

J Figure 1-8. Parent Bomb Racks

1.2.5 Gunner/Copilot Armament Panel. The gunner/copilot armament panel (Figure 1-2) is located on the gunner/copilot right-hand console. The panel consists of an ARM indicator ROUNDS REMAINING counter, TURRET ELEV STOW (turret elevation stow) indicator, GUNNER IN CONT (gunner in control) indicator, STBY (standby) indicator, PILOT OVERRIDE switch, JETTISON SELECT switch, and WING STORES switch.

1.2.5.1 ARM Indicator (Amber). When illuminated, indicates that the pilot has placed his MASTER ARM switch to the arm position, arming all helicopter weapons system. When not illuminated, the wing store armament system and turret system will not be activated by pressing their respective fire buttons.

1.2.5.2 ROUNDS REMAINING Counter. Manually set to register initial rounds quantity and indicates the number of rounds remaining in the turret system.

1.2.5.3 STBY (Standby) Indicator (Green). When illuminated, indicates that the pilot has placed the MASTER ARM switch to the STBY position.

1.2.5.4 GUNNER IN CONT (Control) Indicator (Blue). When illuminated, indicates that the gunner/copilot has control of the turret weapon.

CAUTION

With the TURRET ELEV STOW indicator not illuminated, the turret weapon could impact on the ground during landing.

1.2.5.5 TURRET ELEV STOW Indicator (Green). When illuminated, indicates that the turret system is in the upper stow position for safe landing.

1.2.5.6 PILOT OVERRIDE Switch. Is a two-position positive lock toggle switch which provides the gunner/copilot operation of the wing stores armament management system and turret weapon if the pilot is disabled.

1. OFF position — provides the pilot with normal operation and control of helicopter weapon systems.

2. PILOT OVERRIDE position — electrically by-passes the MASTER ARM switch and all other switches on the pilot armament control panel. The wing stores armament management system and turret weapon are armed and in control of the gunner/copilot, who releases wing stores by pressing the WING ARM FIRE button and fires the turret weapon as a fixed-position weapon (0° azimuth and elevation) by pressing the guarded trigger on his cyclic stick.

1.2.5.7 JETTISON SELECT Switch. The gunner/copilot can jettison wing stores selectively in inboard and/or outboard pairs. Jettison release is initiated by the WING STORES JETTISON switch.

1.2.5.8 WING STORES Switch. With the PILOT OVERRIDE switch set to the PILOT OVERRIDE position, the gunner/copilot can release stores in pairs as selected by the WING STORES switch, by pressing his WING ARM FIRE button.

1. INBD (inboard) — arms the firing circuits to the inboard pair of wing stations (station Nos. 2 and 3).

2. OUTBD (outboard) — arms the firing circuits to the outboard pair of wing stations (station Nos. 1 and 4).

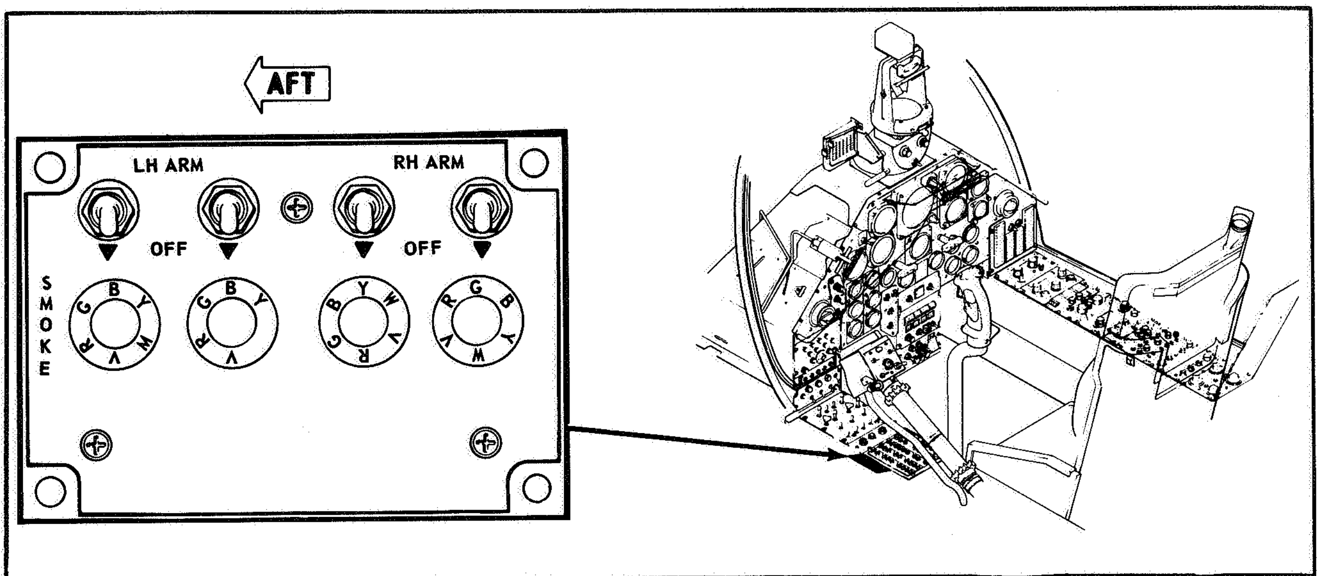
1.2.6 Pilot Smoke Grenade Panel. The pilot SMOKE grenade panel (Figure 1-9) is located above the left console. The control panel provides two switches for station No. 1 dispenser and two switches for station No. 4 dispenser. Four rotary indicators may be manually positioned to B-blue, Y-yellow, W-white, V-violet, R-red, and G-green, to provide a remainder of the color of smoke grenade in each row of corresponding dispenser. Smoke grenades may be released with the MASTER ARM switch in STBY or ARM position, and are released by pressing the SMOKE REL button on the pilot collective pitch control switch box. A headset audio tone is generated when a grenade is released.

1.3 AH-1T WEAPON SYSTEM

The AH-1T armament systems consist of armament control system components, turret system, helmet sight subsystem, wing stores armament system, smoke grenade dispenser system, TOW missile system, and wing stores jettison system.

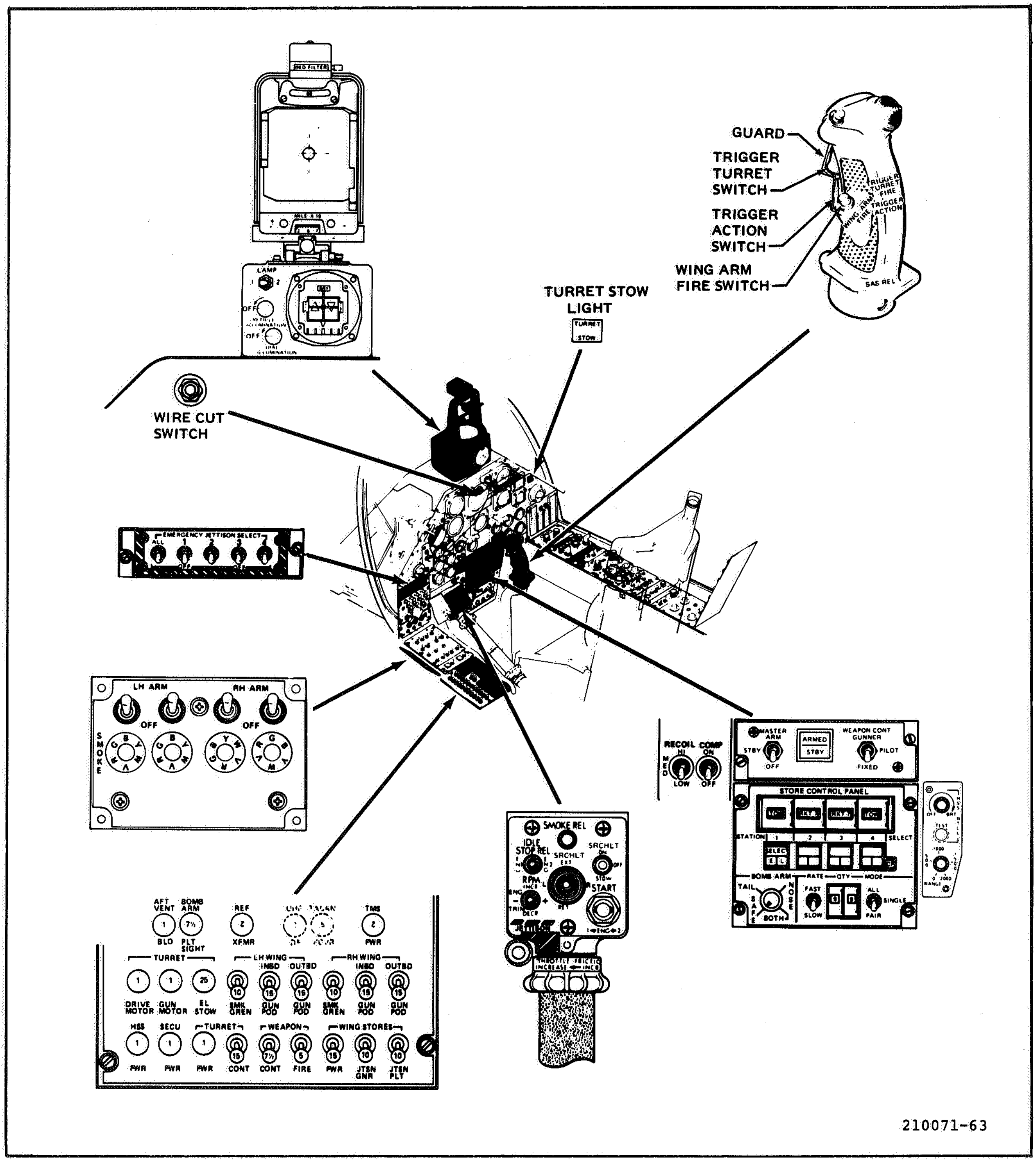
1.3.1 Armament Control System Components. The armament control system components are shown in Figures 1-10 through 1-15. Figures 1-12 through 1-15 illustrate integrated system controls.

1.3.2 Turret System. The GTK4/A49E-7(V) turret system (Figure 1-16) provides for sighting, positioning, ammunition feed, and firing of the M197, 20-mm automatic gun. The system consists of telescopic sight unit (TSU), helmet sight subsystem, turret assembly,

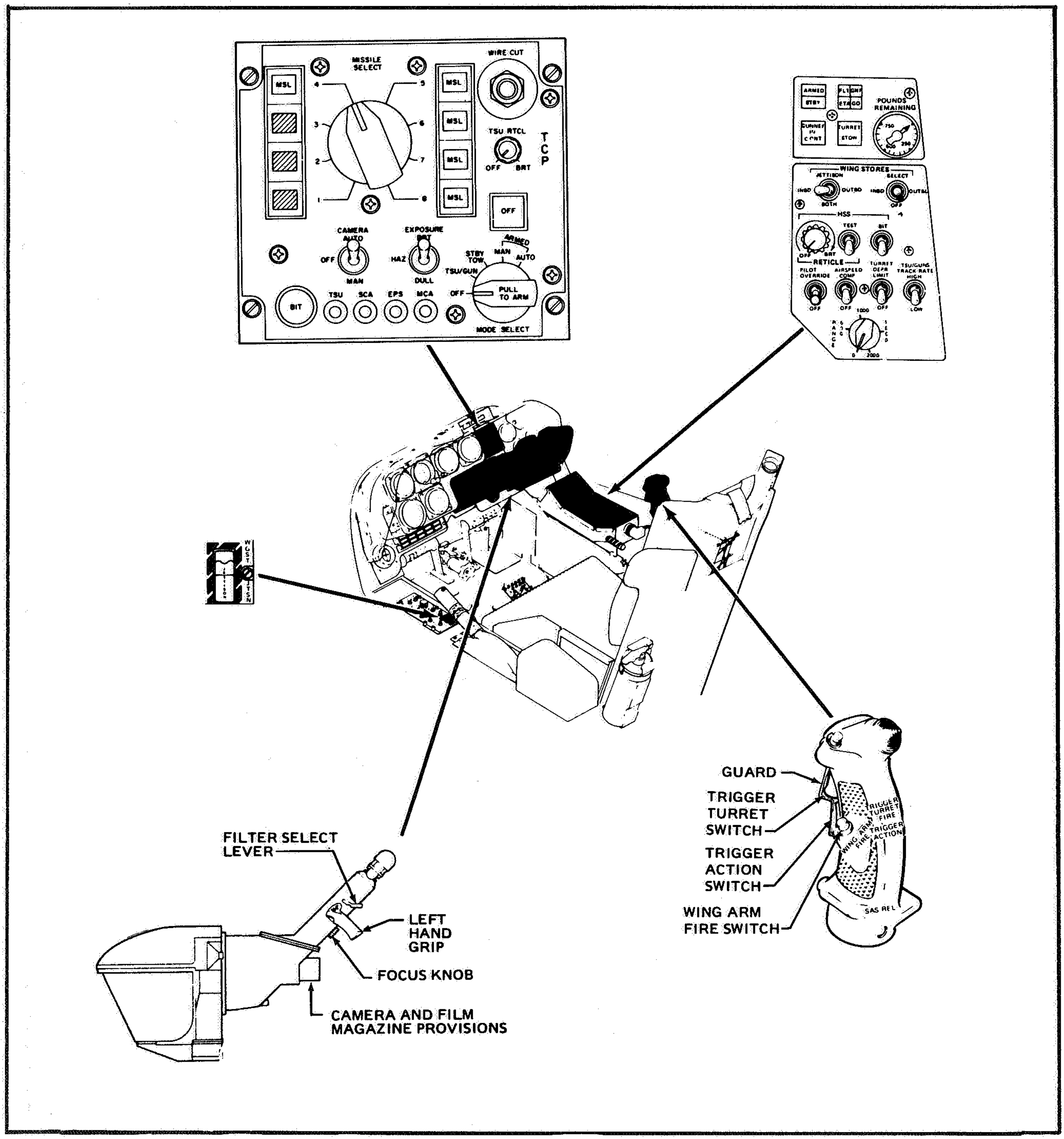


ITEM	FUNCTION
LH ARM switch (aft)	OFF — Disconnects electrical power to station No. 1 smoke grenade dispenser, outboard row. ARM — Selects station No. 1 smoke grenade dispenser, outboard row.
LH ARM switch (forward)	OFF — Disconnects electrical power to station No. 1 smoke grenade dispenser, inboard row. ARM — Selects station No. 1 smoke grenade dispenser, inboard row.
RH ARM switch (aft)	OFF — Disconnects electrical power to station No. 4 smoke grenade dispenser, inboard row. ARM — Selects station No. 4 smoke grenade dispenser, inboard row.
RH ARM switch (forward)	OFF — Disconnects electrical power to station No. 4 smoke grenade dispenser, outboard row. ARM — Selects station No. 4 smoke grenade dispenser, outboard row.
LH manual SMOKE indicator (aft)	B, Y, W, V, R, G — Indicates smoke color in outboard row of station No. 1 smoke grenade dispenser.
LH manual SMOKE indicator (forward)	B, Y, W, V, R, G — Indicates smoke color in inboard row of station No. 1 smoke grenade dispenser.
RH manual SMOKE indicator (aft)	B, Y, W, V, R, G — Indicates smoke color in inboard row of station No. 4 smoke grenade dispenser.
RH manual SMOKE indicator (forward)	B, Y, W, V, R, G — Indicates smoke color in outboard row of station No. 4 smoke grenade dispenser.

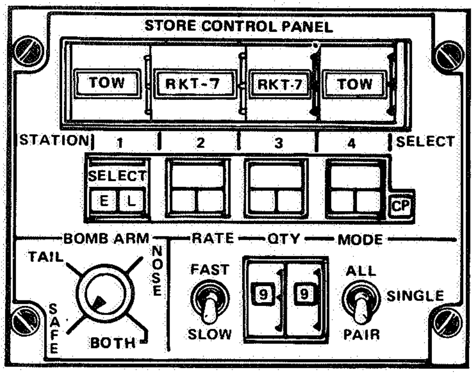
J Figure 1-9. Pilot Smoke Grenade Panel



T Figure 1-10. Pilot Armament Controls and Indicators



T Figure 1-11. Gunner Armament Controls and Indicators



NOMENCLATURE	FUNCTION
THUMBWHEEL REGISTRATION SWITCHES	NOTE Switches must be manually set to indicate weapons installed before weapons can be fired.

EMPTY — Indicates no weapons (Off)
RKT 7 — 7-tube rocket launcher
RKT 19 — 19-tube rocket launcher
GUN PD — GPU-2A
HTW — Helicopter trap weapon
FLARE — Flare
TNG BB — Training bomb
BOMBS — Bomb
RKT 4 — 4-tube rocket launcher
DISP — SUU-44 dispenser
(blank) — Not used
TOW — Indicator only for TOW rack

T Figure 1-12. Pilot Store Control Panel (Sheet 1 of 2)

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NOMENCLATURE		FUNCTION
STATION SELECT	SELECT	— Indicates wing station is selected for firing and weapons are present.
	L	— (For Rockets Only) Indicates five or less rockets remain in 7-tube or 19-tube launcher.
	E	— Indicates weapons are depleted, except for gun pod and TOW.
CP	CP	— Indicates that PILOT OVERRIDE mode is selected and gunner controls turret and wing stores except TOW. Previous station selections are deselected. NARCADS RATE, QTY, MODE, and thumb wheel settings remain applicable.
BOMB ARM	SAFE	— All arming solenoids de-energized.
	TAIL	— Tail arming solenoids energized. Nose arming solenoids de-energized.
	NOSE	— Nose arming solenoids energized. Tail arming solenoids de-energized.
	BOTH	— Both nose and tail arming solenoids energized.
RATE,	FAST	— (For Rockets Only) Sets release rate at 90 milliseconds. (For all wing stores except GUN PD, bomb rate and TOW)
	SLOW	— Sets release rate at 180 milliseconds. (For all wing stores except GUN PD and TOW)
QTY THUMBWHEELS/ INDICATOR		— Select and displays number of fire pulses to be generated in the SINGLE or PAIR mode. (This function is disabled on ALL mode).
MODE	SINGLE	— Opposite wing station weapons of selected like stores to fire alternately.
	PAIR	— Opposite wing station weapons of selected like stores to fire concurrently.
	ALL	— All selected wing station weapons to fire concurrently. QTY select function disabled.

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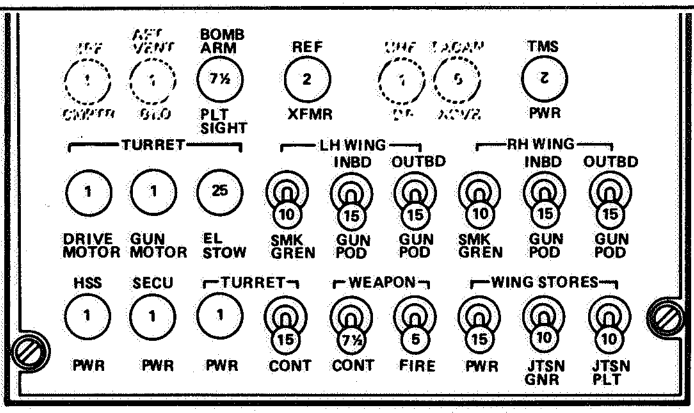
T Figure 1-12. Pilot Store Control Panel (Sheet 2 of 2)



AC/ARMAMENT CIRCUIT BREAKER PANEL

LOCATION: PILOT LEFT CONSOLE

CIRCUIT BREAKER	FUNCTION - APPLIES POWER TO AND PROTECTS CIRCUIT FOR
BOMB ARM/PLT SIGHT	Bomb arming and pilot sight reticle.
REF/XFMR	Reference power for weapon system.
TMS/PWR	TOW missile firing.
TURRET	
DRIVE MOTOR	Turret control.
GUN MOTOR	Weapon rotation
EL STOW	Turret stow.
LH WING	
SMK GREN	Left hand smoke grenade dispenser.
INBD/GUN POD	Left hand inboard gun pod battery charging.
OUTBD/GUN POD	Left hand outboard gun pod battery charging.
RH WING	
SMK GREN	Right hand smoke grenade dispenser.
INBD/GUN POD	Right hand inboard gun pod battery charging.
OUTBD/GUN POD	Right hand outboard gun pod battery charging.
HSS/PWR	Helmet sight subsystem.
SECU/PWR	Servo electronic control unit.
TURRET	
PWR	AC turret control.
CONT	DC turret control
WEAPON	
CONT	Weapon control.
FIRE	Weapon firing.
WING STORES	
PWR	Weapons firing less smoke.
JTSN/GNR	Gunner jettison.
JTSN/PLT	Pilot jettison.

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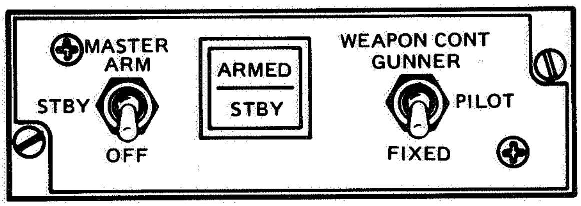
T Figure 1-13. Pilot Armament Circuit Breakers



LOCATION: PILOT INSTRUMENT PANEL

NOMENCLATURE		FUNCTION
MASTER ARM Switch	OFF	Deactivates all sights and weapon control/firing circuits.
	STBY	Activates all sights, turret and TOW missile control circuits, and arms smoke grenade firing circuits. Charges wing gun pod battery. Illuminates pilot and gunner STBY lights.
	ARM	Activates all sights and weapon control/firing circuits. Charges wing gun pod battery. Illuminates pilot and gunner ARMED lights.
WEAPON CONT Switch	FIXED	Permits pilot to fire turret using fixed sight.
	PILOT	Permits pilot to fire turret using HS using fixed sight.
	GUNNER	Permits gunner to fire turret using HS or TSU Illuminates GUNNER IN CONT light on gunner armament panel.
ARMED/STBY Indicator	ARMED	Indicates MASTER ARM switch in ARM (amber light) or gunner PILOT OVERRIDE switch is in OVERRIDE.
	STBY	Indicates MASTER ARM switch in STBY (green light).
	Off	Indicates MASTER ARM switch is off.
	Press	Tests indicator lights.

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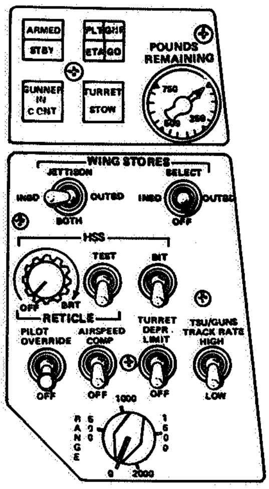
T Figure 1-14. Pilot Armament Control Panel



NOMENCLATURE		FUNCTION
Indicators	ARMED	— Indicates pilot MASTER ARM switch in ARM position.
	STBY	— Indicates pilot MASTER ARM switch in STBY position.
	PLT	— Indicates failure in pilot HS
	GNR	— Indicates failure in gunner HS
	EIA	— Indicates failure in electronic interface assembly
	GO	— Indicates HSS operating properly
	GUNNER IN CONT	— Indicates WEAPON CONT switch on the pilot armament control panel is in GUNNER position.
	TURRET STOW	— Indicates turret in stowed position.

NOMENCLATURE		FUNCTION
ROUNDS REMAINING indicator		Displays number of rounds remaining for the turret weapon.
JETTISON switch	INBD	— Selects inboard stores to be jettisoned.
	BOTH	— Selects all stores to be jettisoned.
	OUTBD	— Selects outboard stores to be jettisoned.
SELECT switch	INBD	— Selects inboard stores to be fired.
	OFF	— Deactivates gunner cyclic firing switches.
	OUTBD	— Selects outboard stores to be fired.
HSS RETICLE switches	OFF-BRT	— Adjust light intensity of gunner HS reticle.
	TEST	— Tests gunner HS reticle lamps (3).
HSS BIT	BIT	— Tests HSS interface assembly and pilot and gunner linkage assembly when both linkage arms are attached to BIT magnet.
PILOT OVERRIDE switch	OVERRIDE	— Overrides pilot armament control. Permits gunner to fire turret using HS, and wing stores without sight (Not TOW or smoke)
	OFF	— Permits pilot armament control panel to control weapons
AIRSPEED COMP switch	COMP	— Applies airspeed data to turret positioning circuits.
	OFF	— Removes airspeed data from turret positioning circuits.

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T Figure 1-15. Gunner Armament Control Panel (Sheet 1 of 2)

NOMENCLATURE		FUNCTION
TURRET DEPR LIMIT switch	TURRET DEPR LIMIT	— Limits downward travel to prevent turret weapons from striking ground.
	OFF	— Permits turret travel between minimum to maximum elevation.
TSU/GUNS TRACK RATE switch	HIGH	— Provides fast slew rates for TSU regardless of LHG MAG switch position.
	LOW	— Provides slow slew rates for TSU when LHG MAG switch in LO position.
RANGE switch	0-2000	— Provides meters — to — target data to compensation circuit.

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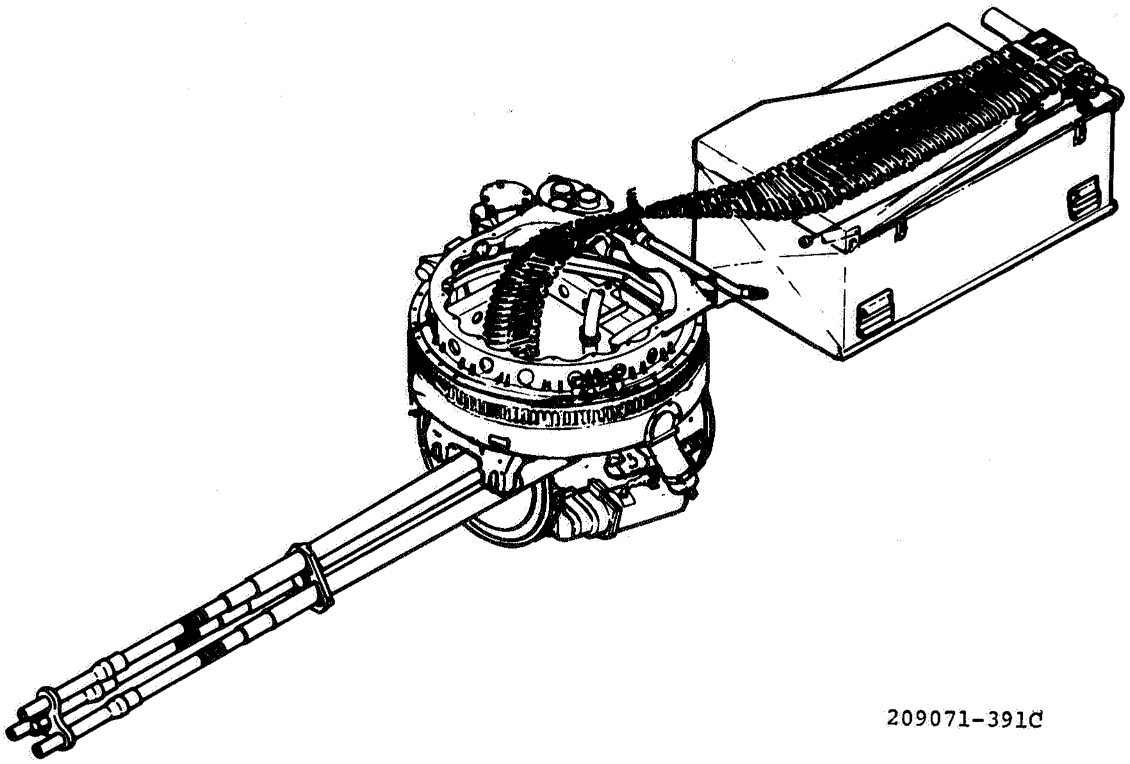
T Figure 1-15. Gunner Armament Control Panel (Sheet 2 of 2)

ammunition box, and ammunition feed system. The turret system is electrically operated by 28 vdc and 115 vac, 400-Hz power from the helicopter electrical system. Application of power to energize the turret system is controlled by circuit breakers on the ac/armament circuit breaker panel (Figure 1-13). A PILOT OVERRIDE switch is provided on the gunner armament control panel (Figure 1-15) to allow the gunner to by-pass pilot control operation of the turret system.

1.3.2.1 Functions. The turret assembly, which is chin mounted on the helicopter, provides mounting for the M197 20-mm automatic gun. Electrical circuits in the turret control assembly and turret assembly provide remote control for azimuth and elevation drive system in the turret. The azimuth drive system rotates the turret through a range of 110° either side of 0° azimuth. The gun can be lowered 50° below elevation. The gun control assembly controls operation and firing of the gun and operation of the ammunition feed system. The gun control assembly also supplies firing voltage and



T Figure 1-16. Turret

supplies it to the gun when gun drive power is applied. The gun drive assembly rotates gun barrels at a firing rate of approximately 630 ± 50 rounds per minute. Power applied to the ammunition feed system operates booster assembly on the ammunition box and energizes a declutching solenoid on the gun feeder. The booster assembly and gun feeder provide a flow of ammunition from the ammunition box. The ammunition feed system contains 750 rounds of belted 20-mm ammunition. The gun is fired for duration of trigger command signal plus clearing cycle, or in limited 16 ± 4 round bursts. The first detent on the cyclic trigger (Figure 1-17) or LHG trigger allows gun control assembly to automatically terminate each trigger command signal after 16 ± 4 rounds are fired. The second detent allows continuous firing. The turret and wing stores cannot be fired simultaneously.

1.3.2.2 Modes of Operation. The turret modes of operation include pilot mode, fixed forward, gunner mode, and pilot override.

1. Pilot Mode (Figure 1-18) — WEAPON CONT switch positioned to PILOT, the gun is controlled in azimuth and elevation by the pilot helmet sight. WEAPON CONT switch positioned to FIXED, the gun remains in a forward fixed position at 0° azimuth and elevation, and the fixed sight is used. The gun is fired with a guarded trigger on the pilot cyclic grip.

2. Gunner Mode (Figure 1-19) — during gunner control operation, the gun is controlled by TSU or helmet sight. The gun can be fired from the left-hand grip (LHG) or cyclic grip.

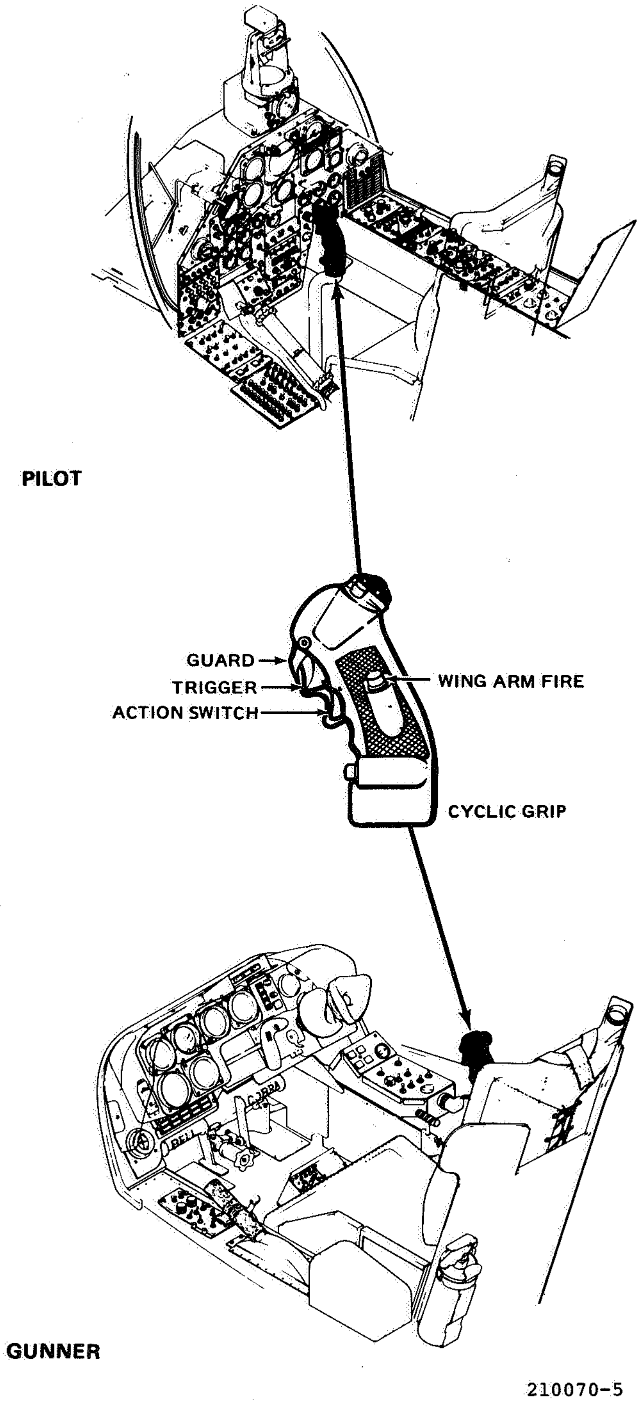
3. Pilot Override (Figure 1-20) — the PILOT OVERRIDE switch is located on the gunner armament control panel (Figure 1-15). When in OVERRIDE, the switch electrically by-passes the MASTER ARM switch and all other switches on the pilot armament control panel. The CP light on the pilot STORE CONTROL PANEL illuminates, GUNNER IN CONT light illuminates, pilot and gunner ARMED lights illuminate, and TCP system status annunciator displays OFF. Armament systems are armed and controlled by the gunner with the exception of TOW and smoke grenade release. The TSU is disabled during PILOT OVERRIDE operation; however, the turret can be controlled by the HS. The gunner can then fire the turret by depressing the cyclic TRIGGER. Wing stores can be released or fired by placing gunner armament control panel WING STORES SELECT switch in INBD or OUTBD and depressing cyclic WING ARM FIRE button. When gunner places WING STORES SELECT switch to INBD, stations 2 and 3 are selected. When placed to OUTBD, stations 1 and 4 are selected. Placing the switch to OFF deselects all previously selected stations. Rockets RATE, QTY, and MODE settings remain valid. BOMB ARM settings also remain valid. OFF position of PILOT OVERRIDE switch allows normal control and operation of armament systems.

1.3.3 Helmet Sight Subsystem (HSS). The HSS (Figure 1-21) permits pilot or gunner to rapidly acquire visible targets and to direct turret and telescopic sight unit (TSU) to those targets. The HSS also provides a means of cueing between pilot and gunner for target location.

The HSS consists of two helmet sight (HS) assemblies mounted to the pilot and gunner helmets, two linkage assemblies mounted to the cockpit left canopy frame, and an electronic interface assembly mounted to the rear cockpit bulkhead.

Aiming of weapons is accomplished by superimposing the reticle image on the target. The reticle image is projected by a reflex sight in front of the operator's right eye, and appears as a yellow/white pattern focused at the target range.

The turret or TSU is directed by moving the head until a reticle image is on the target.



T Figure 1-17. Cyclic Grip Armament Controls

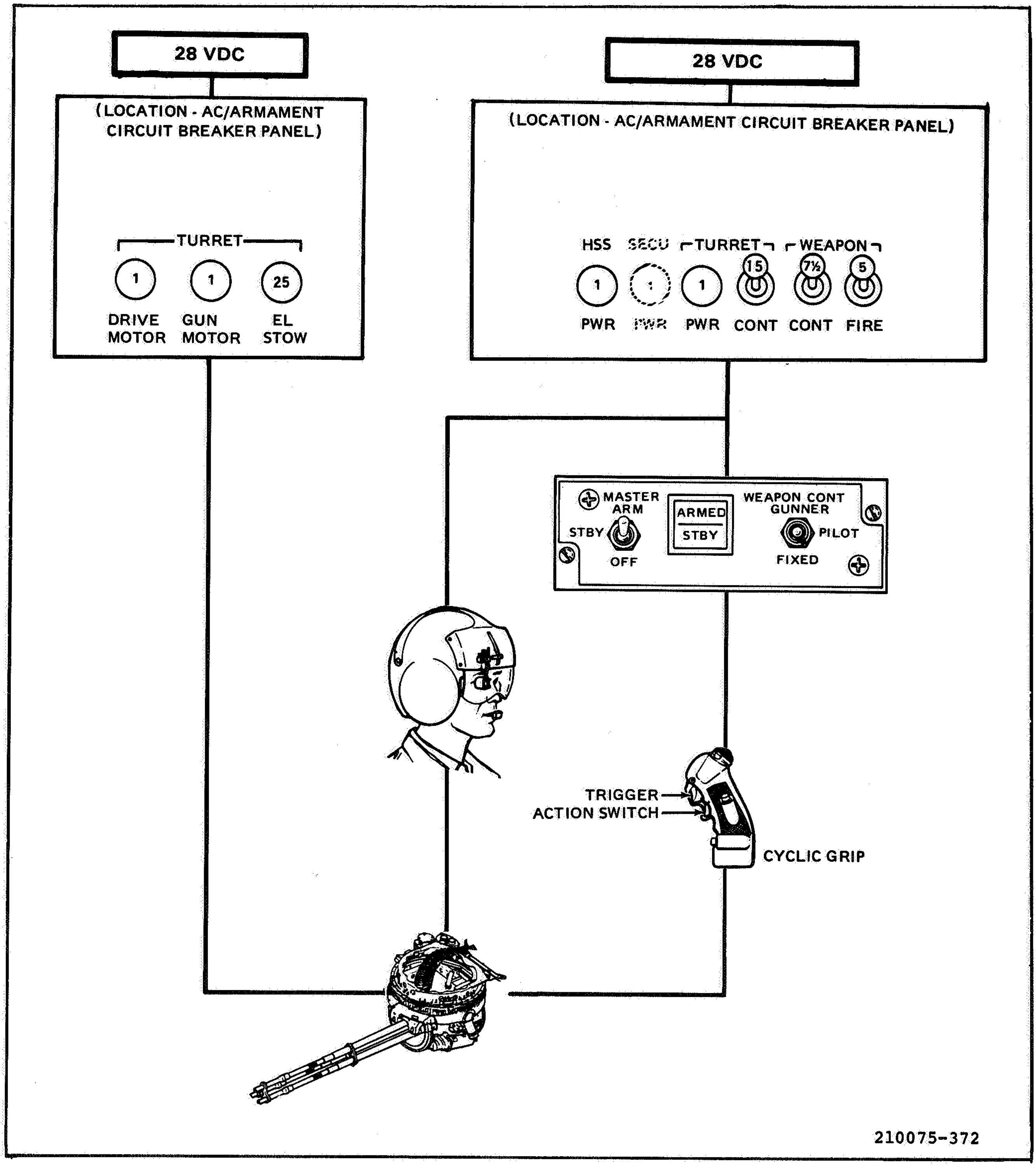
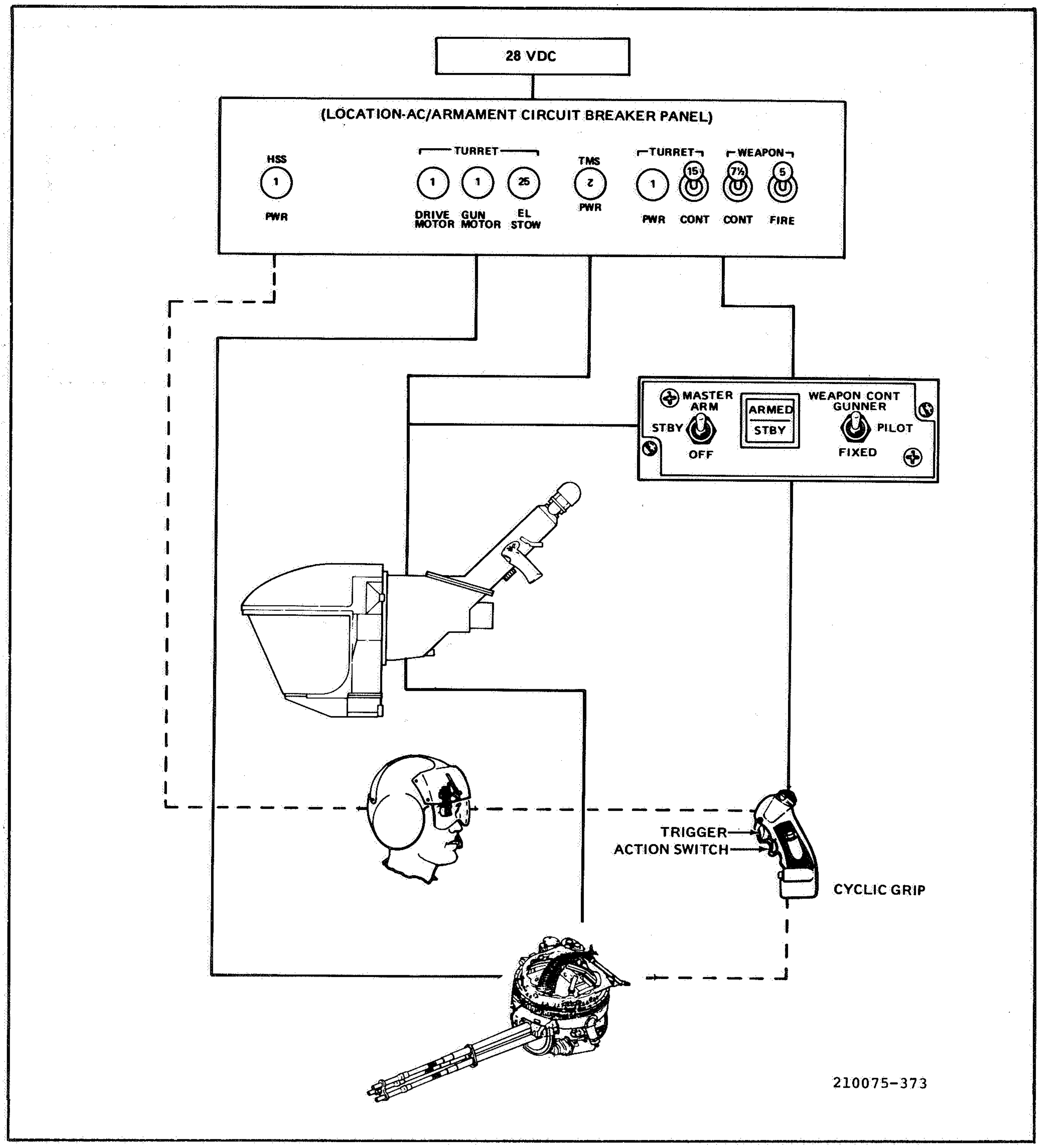
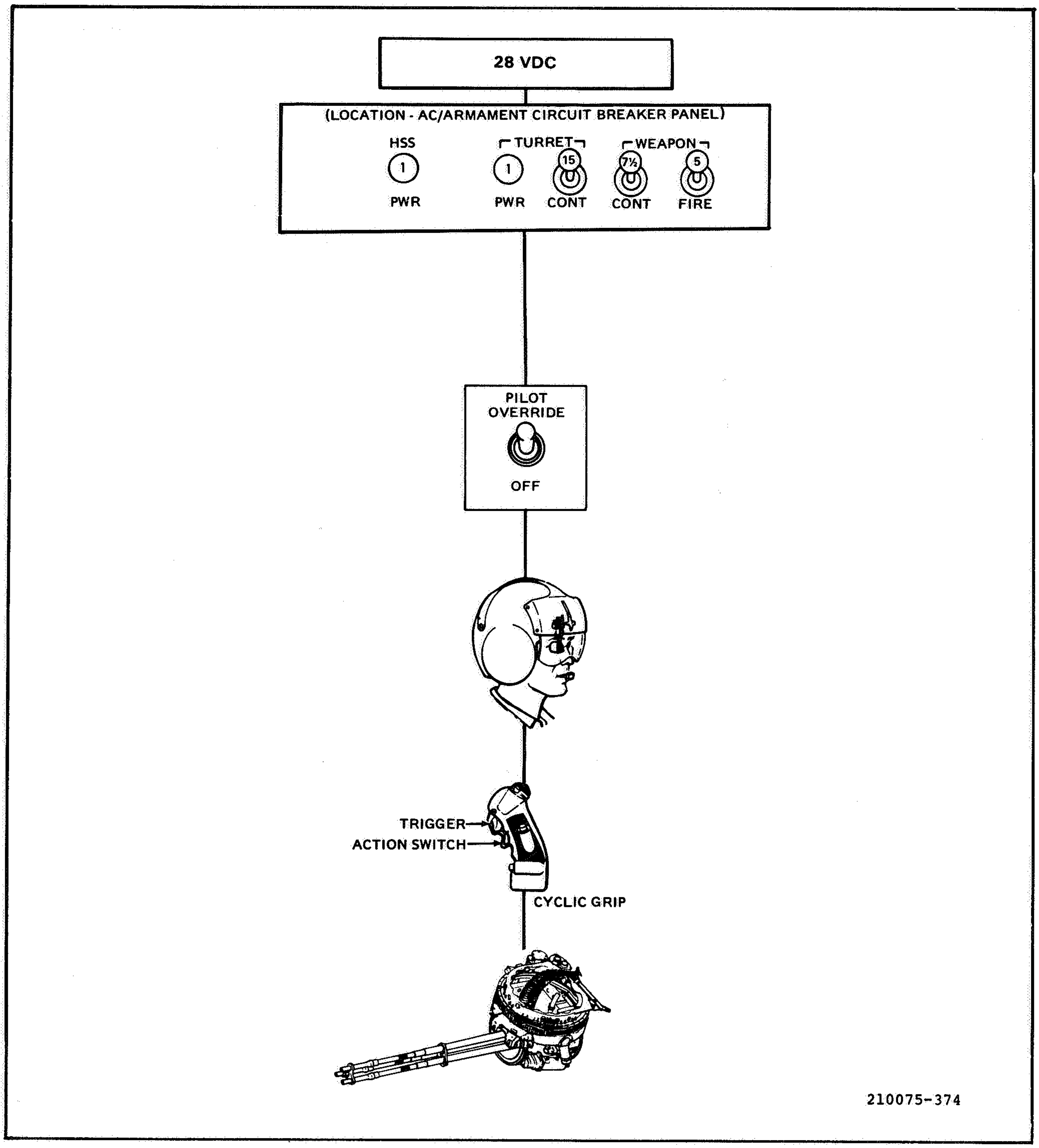


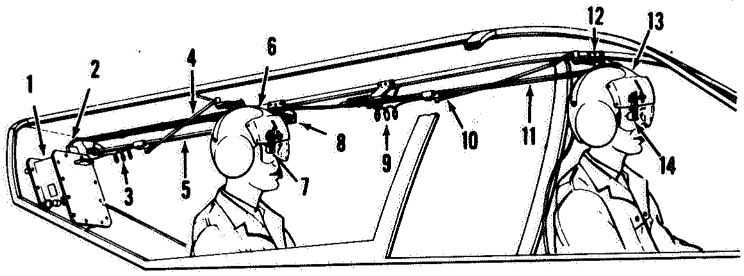
Figure 1-18. Pilot Turret Firing Diagram



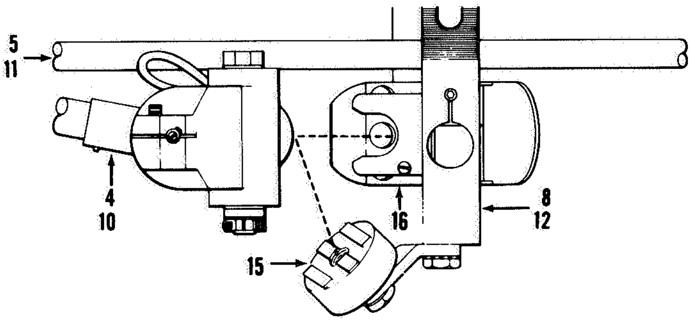
T Figure 1-19. Gunner Control Turret Firing Diagram With Pilot Override Switch Off



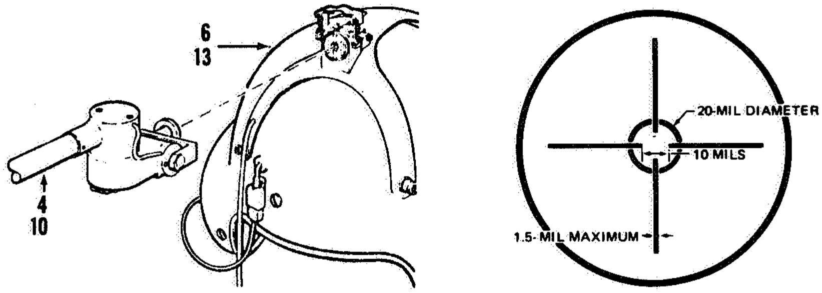
T Figure 1-20. Gunner Control Turret Firing Diagram in Pilot Override Mode



HELMET SIGHT SUBSYSTEM



PILOT/GUNNER LINKAGE ARM ATTACHMENT TO BIT MAGNET AND STOW BRACKET



PILOT/GUNNER LINKAGE ARM ATTACHMENT TO HELMET SIGHT

PILOT/GUNNER EYEPIECE RETICLE PATTERN

1. **Electronic Interface Assembly**
2. **Gunner Extension Cable**
3. **Pilot Linkage Cable**
4. **Pilot Linkage Arm**
5. **Pilot Linkage Rails**
6. **Pilot Helmet Sight**
7. **Pilot Eyepiece**
8. **Pilot Linkage Front Support**
9. **Gunner Linkage Cable**
10. **Gunner Linkage Arm**
11. **Gunner Linkage Rails**
12. **Gunner Linkage Front Support**
13. **Gunner Helmet Sight**
14. **Gunner Eyepiece**
15. **BIT Magnet**
16. **Stow Bracket**

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T Figure 1-21. Helmet Sight Subsystem (HSS)

Error signals will cause the turret or TSU to move until they are aligned with the HS.

The linkage assemblies are equipped with stow brackets integral with the front mounting brackets. A magnet on the helmet sight holds the linkage to the helmet. The linkage must be connected to the helmet sight before the gun will fire (or left in stow position) or before the reticle will illuminate.

Each HSS assembly has a cable terminating in an eight-pin connector. This connector must be attached to the mating jack located on the side of the seat in the same clip as the communications connector. After the HS assembly has been connected and the linkage attached, the sight eyepiece must be positioned in front of the eye. To adjust the eyepiece vertically, compress the ends of the spring lock with the left hand and move the eyepiece up or down with the right hand. To adjust the sight laterally, grasp the sight housing firmly and apply enough lateral force to overcome the effect of the friction disc and cause the housing to move.

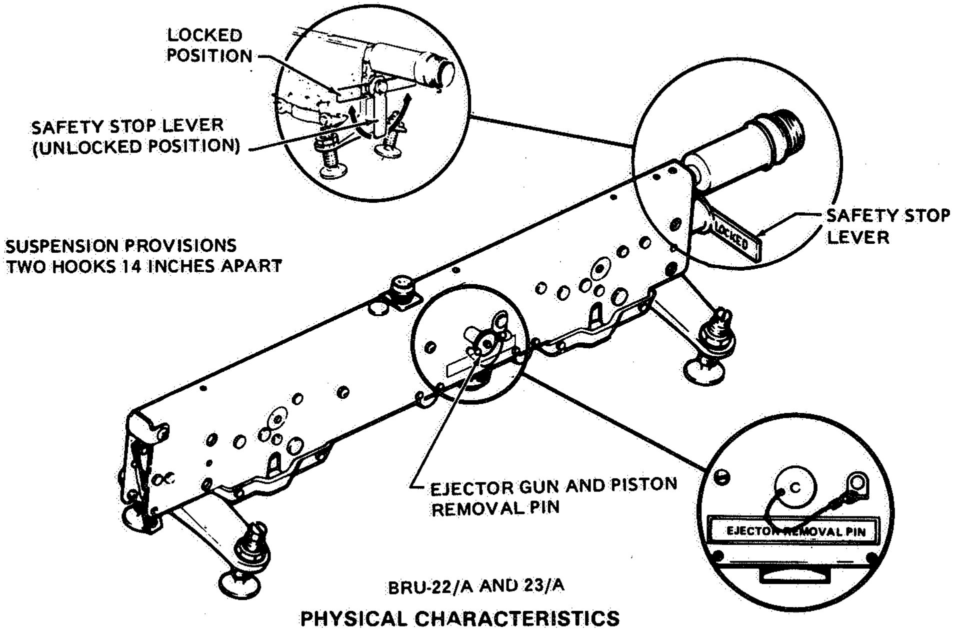
The HSS assembly can be retracted (rotated out of the field of view) manually. To retract the sight manually, push the small button located to the right of the bulb cover. The sight will rotate ccw out of the field of view. The signal for electrically retracting the gunner sight occurs when the gunner moves the STOW/TRK/ACQ switch from the ACQ position to the TRK position or when the switch is in the TRK position and the PHS ACQ switch is depressed. The signal moves the sight out of the way automatically before the gunner looks into the TSU. The sight, once retracted, must be manually returned to the field of view by rotating the sight cw until it latches in front of the eye.

The turret is positioned in azimuth and elevation by moving the HS, with the linkage attached, while the turret action switch on TSU left-hand grip (LHG) is depressed. Vertical movement of the head will produce elevation movement of the turret, and horizontal movement of the head will produce azimuth movement of the turret. Release of the action switch will cause the turret to return to the stow position regardless of HS position. If the action switch is depressed and the sight moved at a speed greater than the maximum angular velocity of the turret, the firing circuit is interrupted, and the sight reticle flashes until the gun is coincident within 5.5° of the HS line of sight. The sight reticle also flashes when turret is against azimuth or elevation limits.

HSS reticle OFF-BRT knobs and TEST switches are located on the pilot instrument panel and the gunner armament control panel. An HSS BIT switch on the gunner armament control panel tests the HSS. PLT (pilot), GNR (gunner), and EIA (electronic interface assembly) failure indicator lights plus a GO (HSS operating properly) indicator light are also located on the gunner armament control panel.

1.3.4 Wing Stores Armament System. Four hard point stations are provided, two under each wing. The pylon assemblies include external store racks, sway braces, and standard electrical connections for external stores. The entire assembly is enclosed in a fairing that matches the lower contour of the wing. The ejector rack of each pylon is equipped with an electrically-operated ballistic jettison device. The jettison system consists of a breech block that utilizes cartridges with independent firing circuits. The inboard stations incorporate a BRU-22/A rack on inboard left side and BRU-23/A rack on inboard right side (Figure 1-22). Articulated ejector racks are installed on the outboard stations (Figure 1-22.) Control release diagrams are shown in Figures 1-23 through 1-29.

1.3.5 Smoke Grenade Dispenser System. The SMOKE control panel is located on the pilot left bulkhead (Figure 1-30). The color of smoke grenades in each rack is set on a color indicating dial located below the ARM switch for each rack. To select grenades of a desired

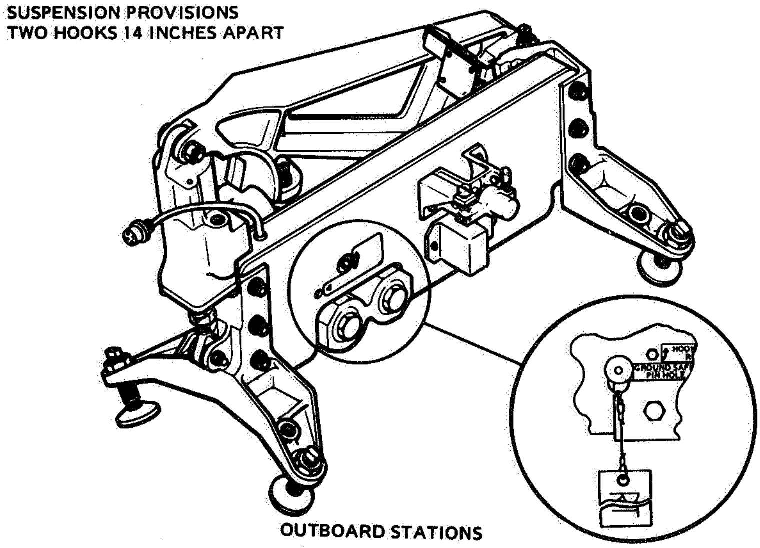

LOCKED POSITION
SAFETY STOP LEVER (UNLOCKED POSITION)
SUSPENSION PROVISIONS TWO HOOKS 14 INCHES APART
LOCKED
SAFETY STOP LEVER
EJECTOR GUN AND PISTON REMOVAL PIN
C
EJECTOR REMOVAL PIN

BRU-22/A AND 23/A

PHYSICAL CHARACTERISTICS

Length:	24.15 in
Height:	5.31 in
Width:	6.37 in
Weight:	11.70 lb

INBOARD STATIONS



BHT PART NO. 209-071-243-7

PHYSICAL CHARACTERISTICS

Length:	19.25 in
Height:	12.50 in
Width:	9.75 in
Weight:	32.80 lb

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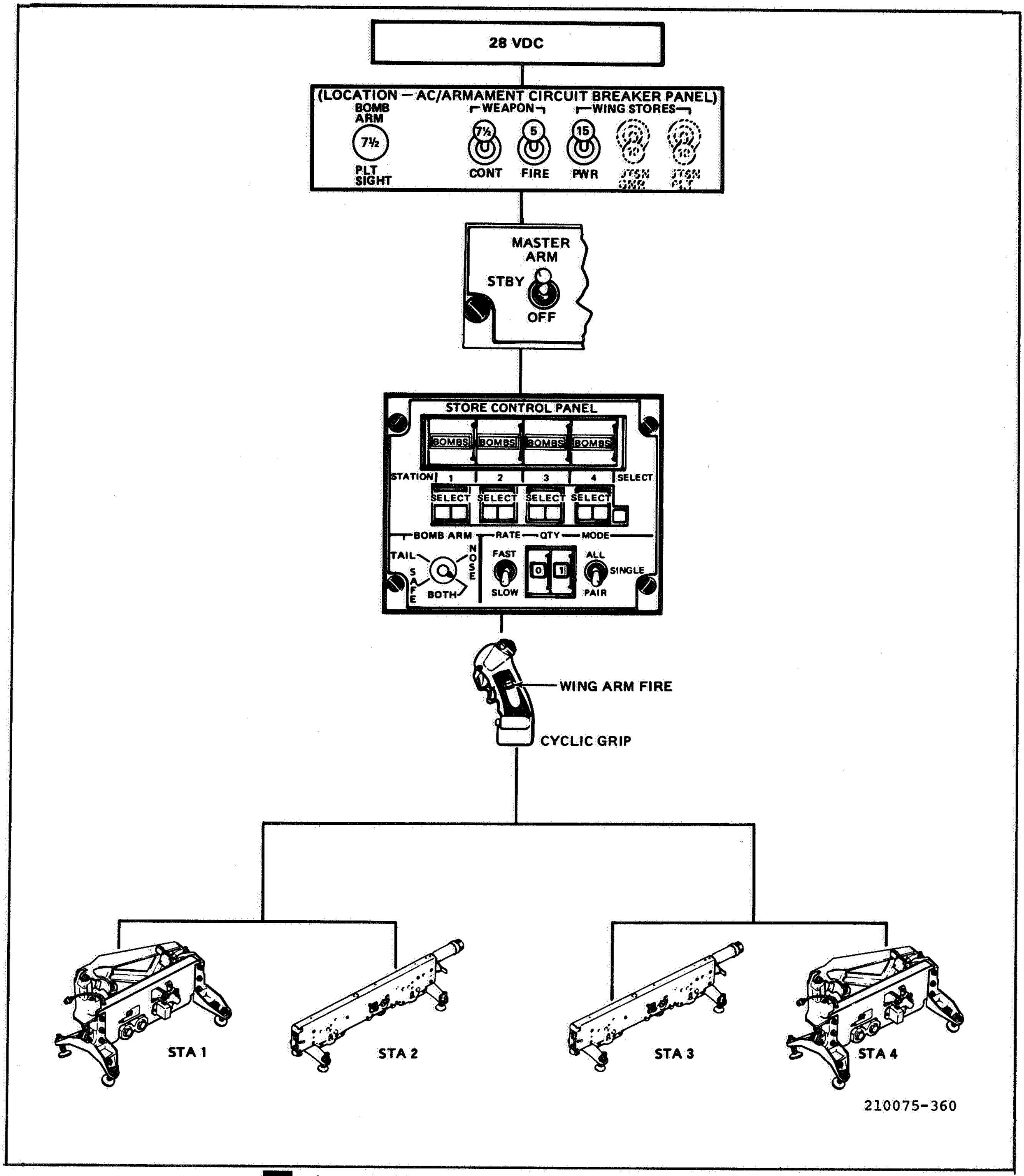
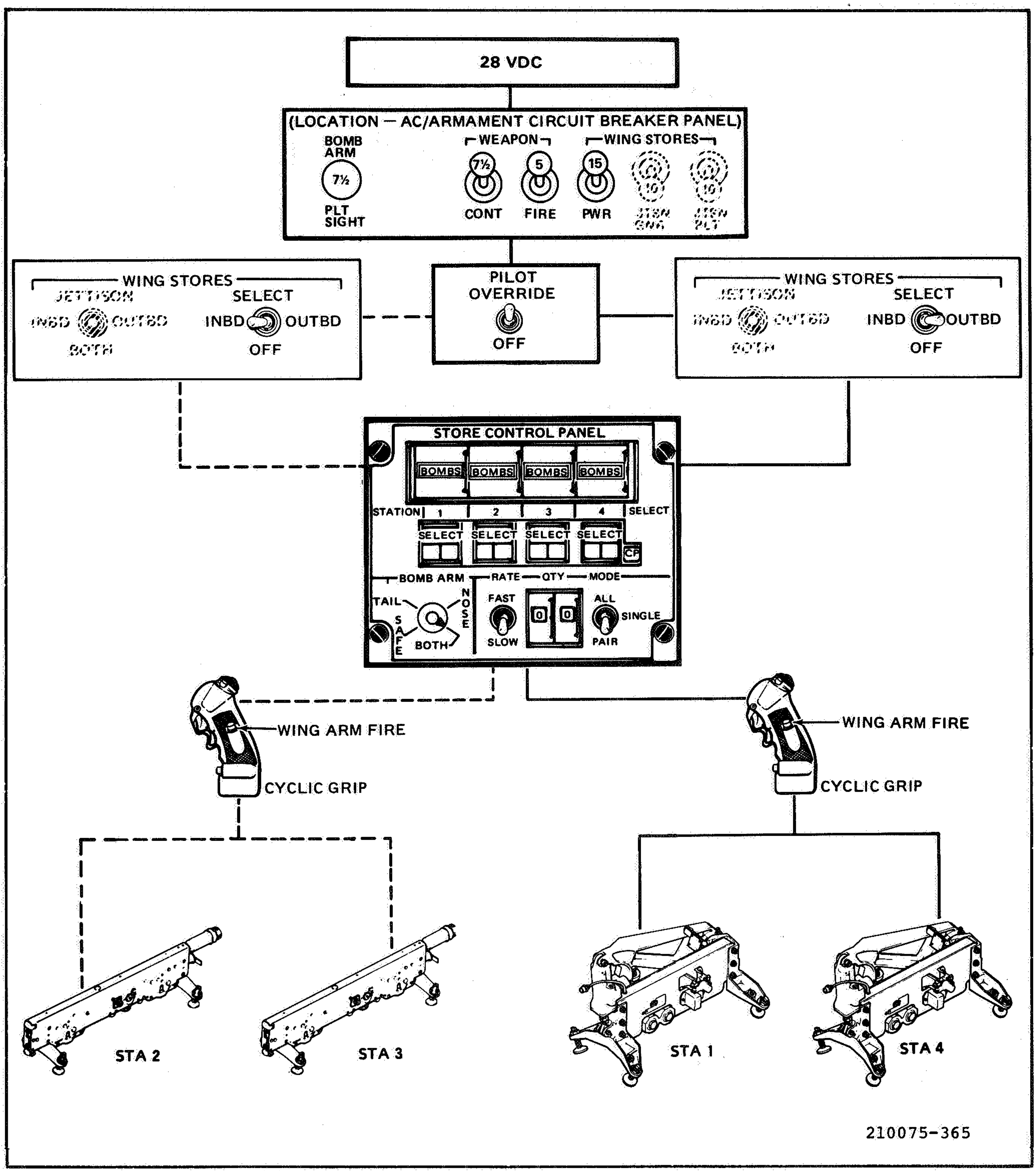
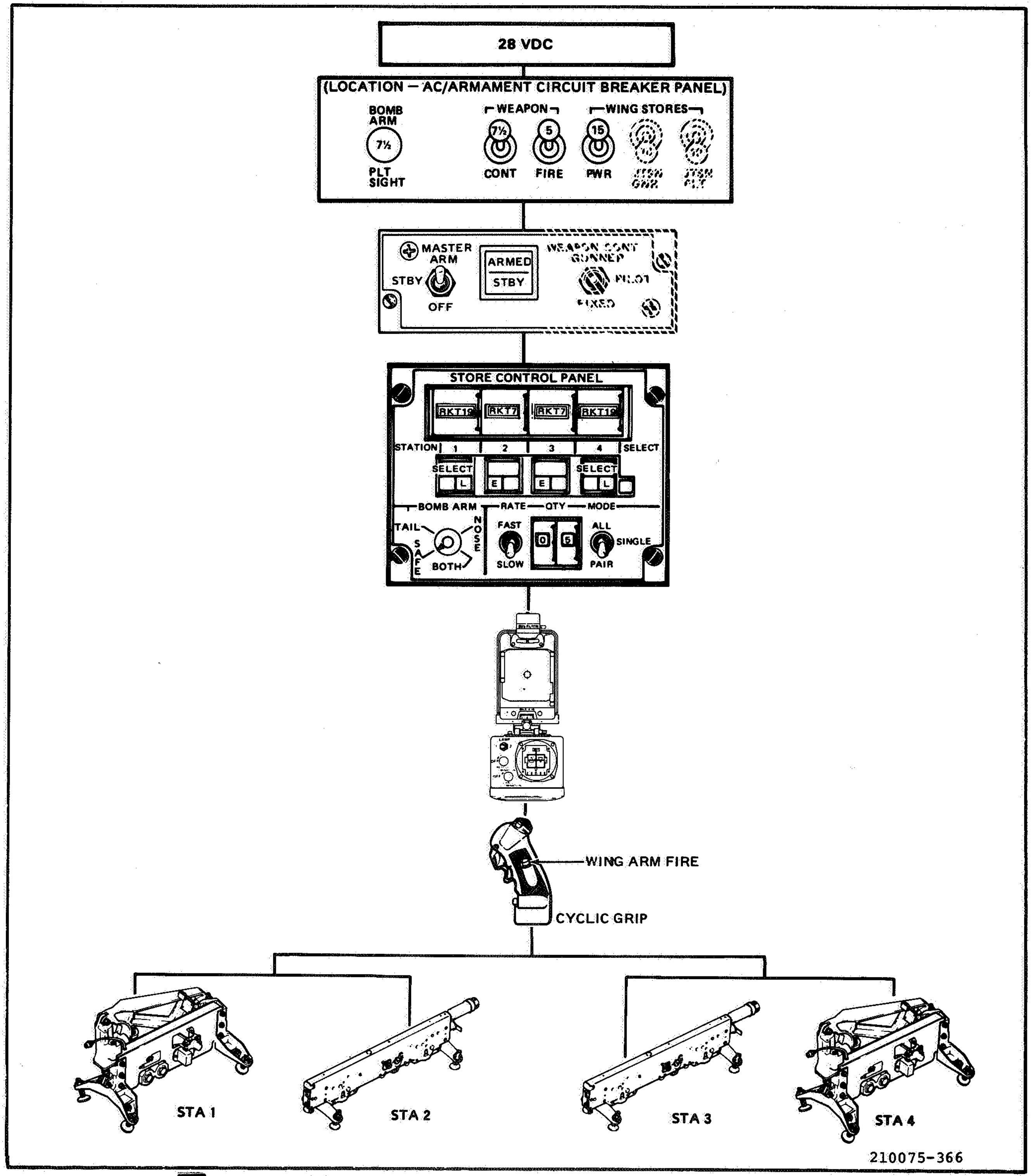
Figure 1-22. Parent Racks



T Figure 1–23. Pilot Normal Release Diagram



T Figure 1-24. Gunner Normal Release Diagram



T Figure 1-25. Pilot Rocket Firing Diagram With Pilot Control

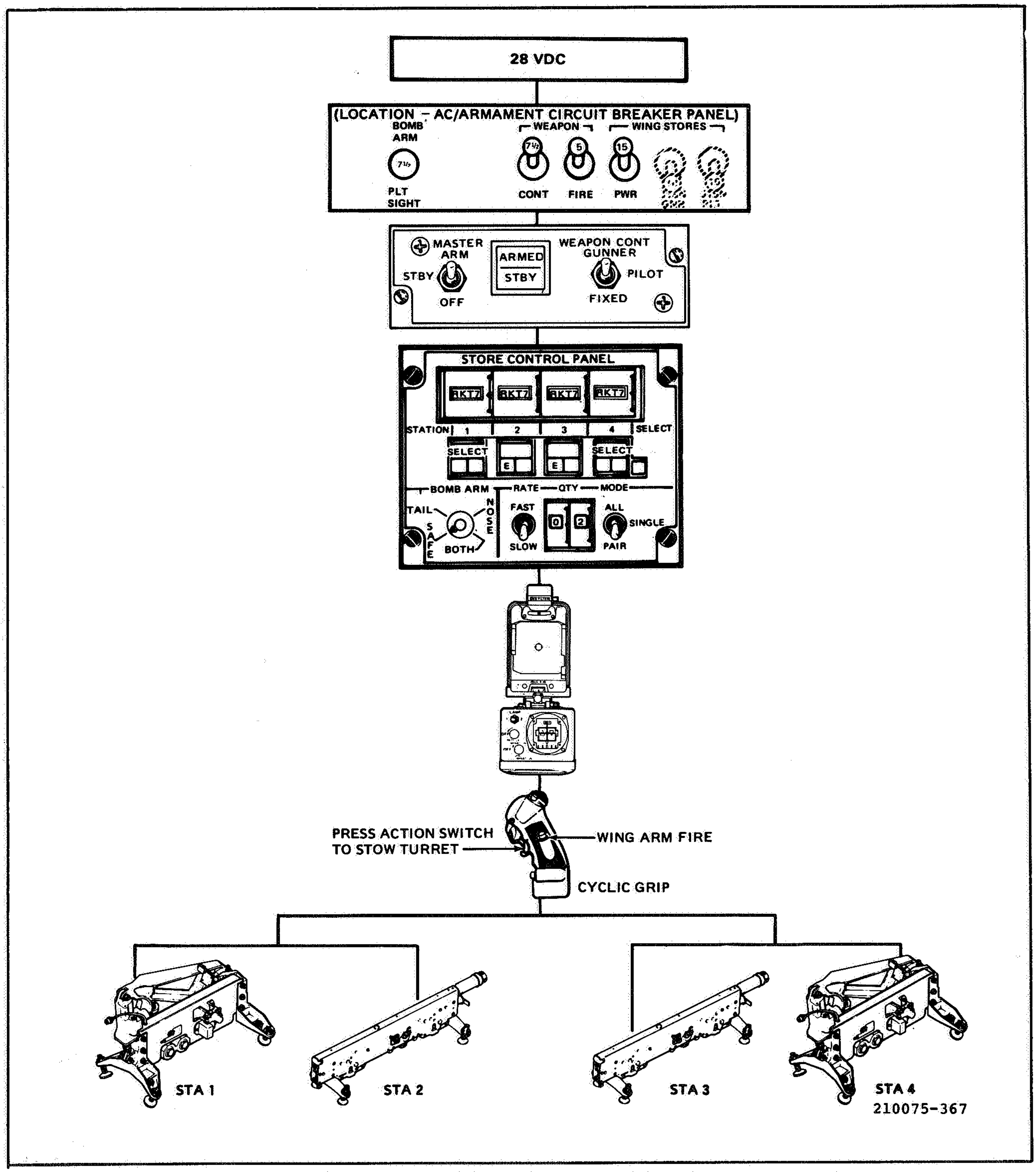
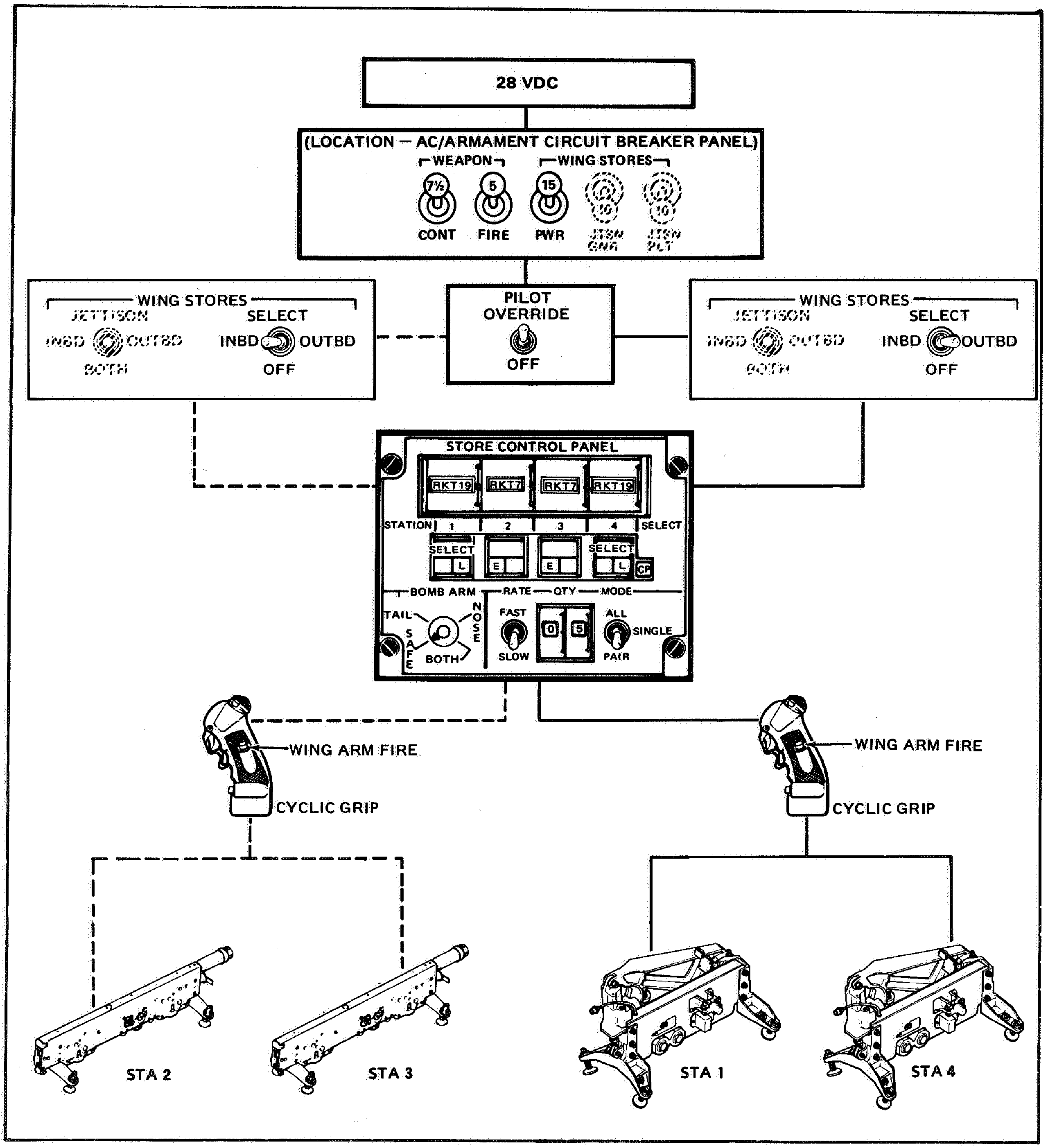


Figure 1–26. Pilot Rocket Firing Diagram With Gunner Control



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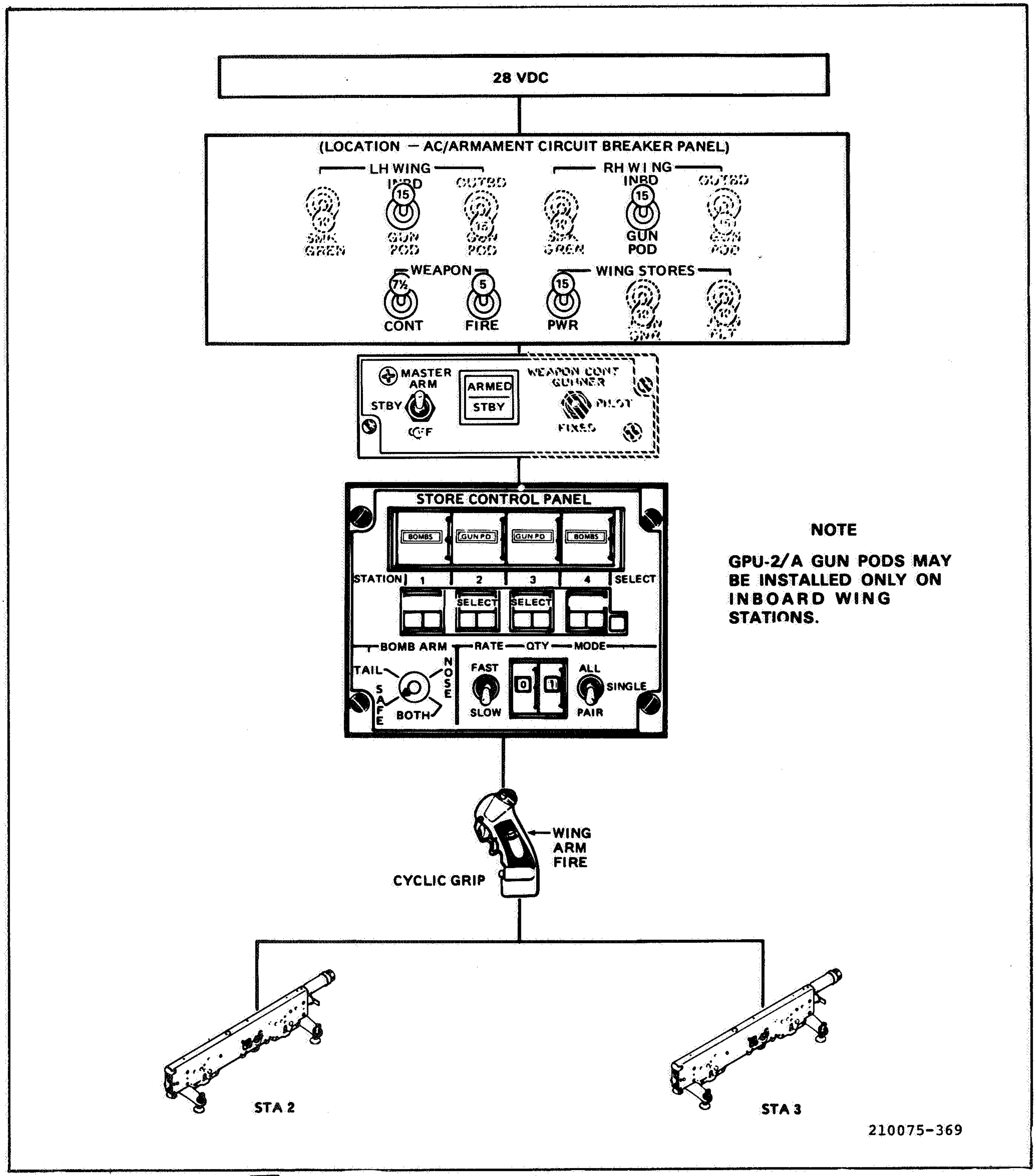
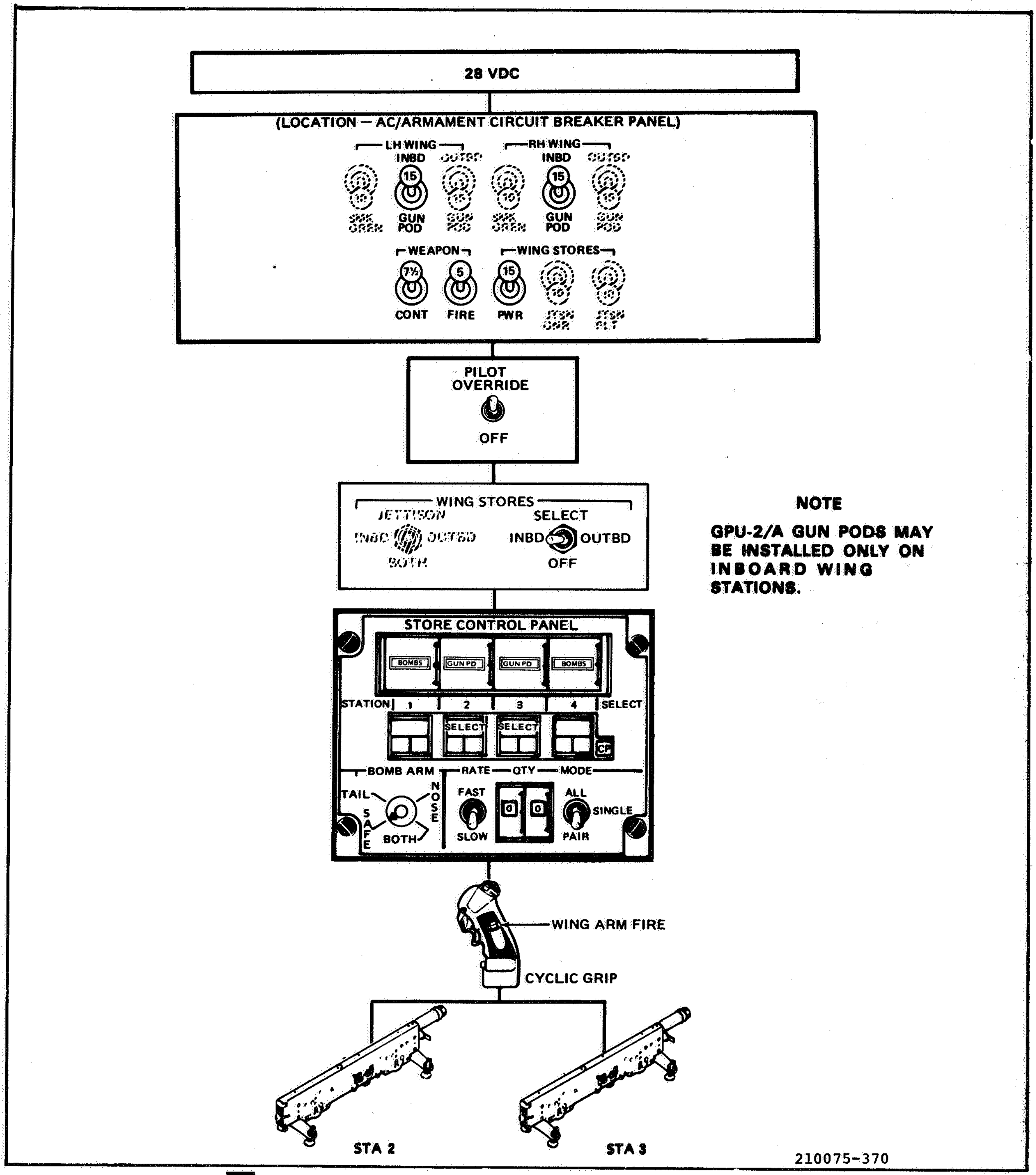
T Figure 1-27. Gunner Rocket Firing Diagram With Override Switch Energized



NOTE

GPU-2/A GUN PODS MAY BE INSTALLED ONLY ON INBOARD WING STATIONS.

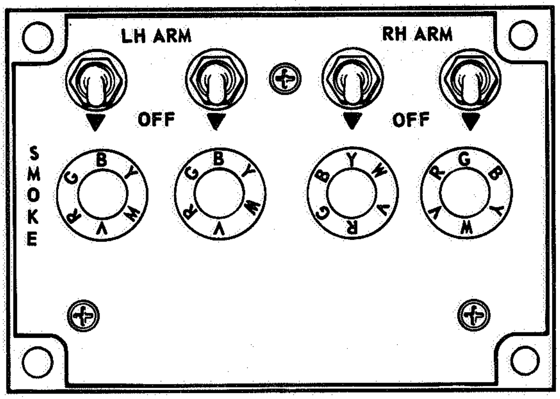
T Figure 1-28. Pilot Wing Gun Pod Firing Diagram



NOTE

GPU-2/A GUN PODS MAY BE INSTALLED ONLY ON INBOARD WING STATIONS.

T Figure 1-29. Gunner Wing Gun Pod Firing Diagram



LOCATION: PILOT LEFT BULKHEAD

NOMENCLATURE	FUNCTION	
* LH ARM Switches	OFF	— Deactivates left wing smoke grenade circuit.
	LH ARM	— Permit pilot to fire left wing smoke grenades.
* RH ARM Switches	OFF	— Deactivates right wing smoke grenade circuit.
	RH ARM	— Permit pilot to fire right wing smoke grenades.
* Color Indicators	B, Y, W, V, R,G	— Indicates color of grenades installed. B — Blue Y — Yellow W — White V — Violet R — Red G — Green

* One for each rack of each dispenser (total of two per dispenser)

210075-278

T Figure 1-30. Pilot Smoke Grenade Dispenser Control Panel color, the pilot actuates the ARM switch directly above the color indicating dial set to the desired color. Pressing the SMOKE REL button on the pilot collective switch box (Figure 1-31) drops one grenade from each of four racks selected and causes a 400-cycle audio tone in the pilot's headset. The pilot hears the same audio tone regardless of how many grenades he is firing simultaneously, and the tone is heard as long as the SMOKE REL button remains depressed. When the last grenade from a rack has been fired, the tone continues until the ARM switch for the particular rack is placed OFF.

1.3.6 TOW Missile System. The TOW (tube-launched, optically tracked, wire command-link) missile subsystem consists of a TOW control panel (TCP), pilot steering indicator (PSI), telescopic sight unit (TSU), sight hand control (SHC), and TOW missile launchers (TML) (Figure 1-32).

1.3.6.1 TOW Control Panel. The TOW control panel provides controls and indicators for manual and automatic TOW missile selection, gun selection, missiles onboard, TMS power control, built-in-test (BIT) control and status, manual wire cut switch, and camera operation and exposure controls. The TCP is located in the gunner's instrument panel. (Figure 1-33.)

1.3.6.1.1 Built-in-Test (BIT) Failure

1. TCP BIT button — depress.

2. ReBIT up to eight times. If a white BIT ball is still present, contact maintenance for further assistance.

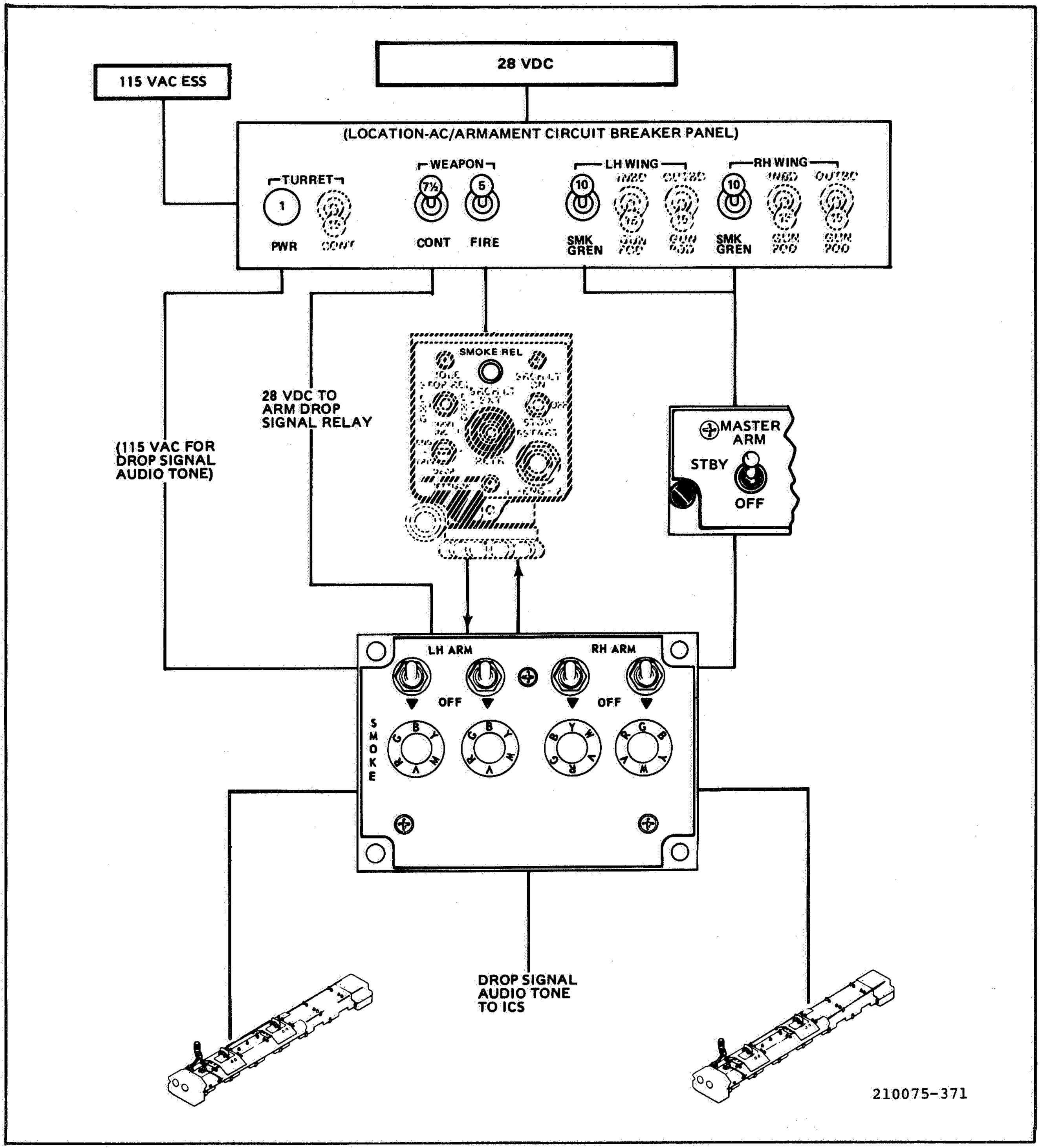
3. The TMS should have at least two consecutive successful ReBITs before the system is considered ready.

1.3.6.2 Pilot Steering Indicator (PSI). The PSI is located in the pilot sight. The PSI provides the pilot with steering information for prelaunch helicopter alignment or postlaunch maneuver. The PSI aids the pilot in aligning the helicopter to the target by displaying TSU line of sight with respect to helicopter line of sight. It also provides for indication to the pilot that the gunner has started attack and that a TOW missile can be fired. Indications are also provided to tell the pilot that the launch sequence has been initiated. In addition, the azimuth and elevation TSU gimbal limits are indicated (Figure 1-34).

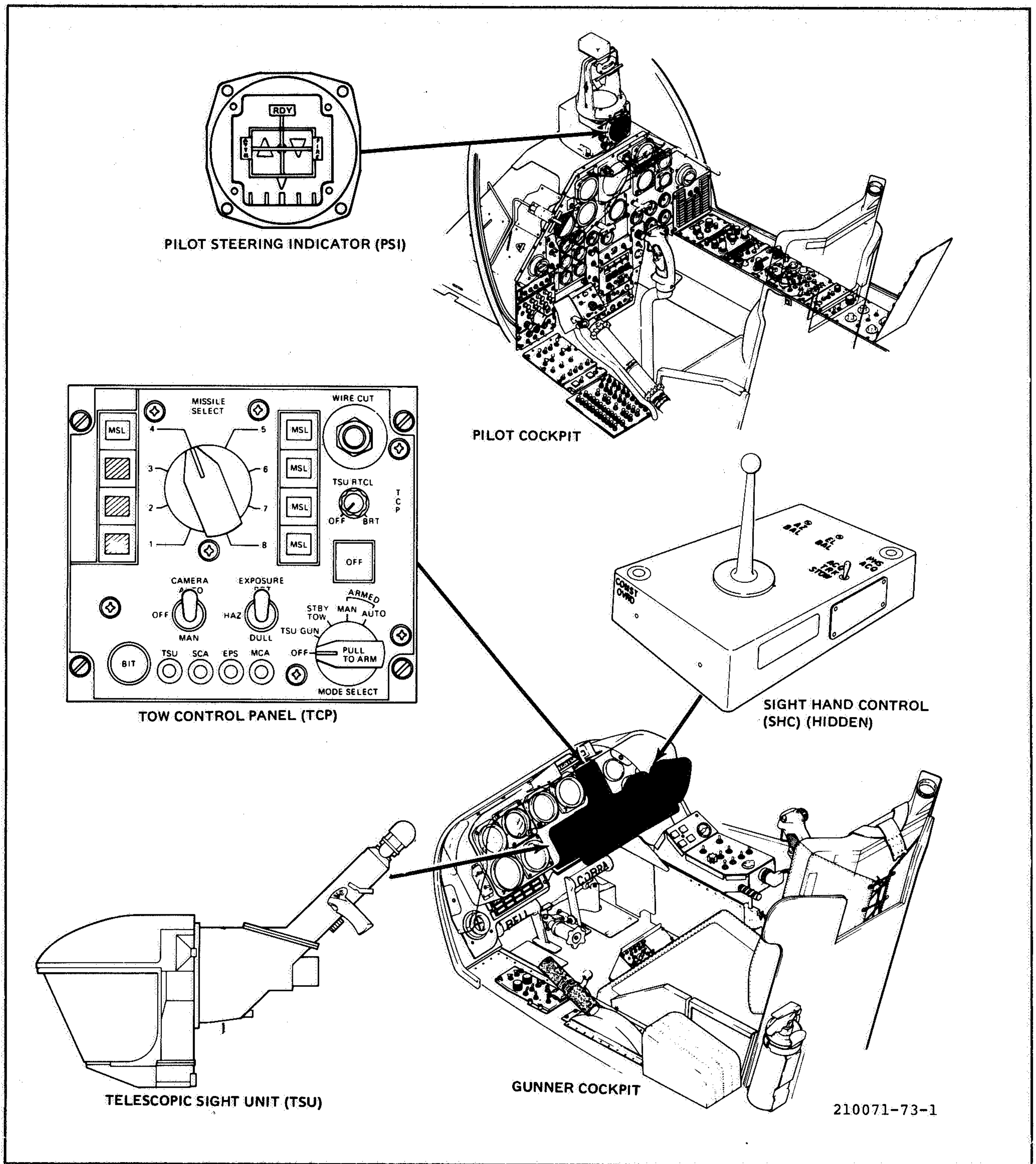
1.3.6.3 Telescopic Sight Unit. The TSU contains the optical system necessary for firing the TOW missile or the turret weapons. The TSU is movable in both azimuth and elevation to provide target acquisition and tracking capabilities. The TSU contains the IR tracker and error detector to measure the missile displacement from the optional line of sight. The TSU also contains provisions for a gun camera for recording missile firings. The TSU has provisions for a laser ranging system to be used in the future. The TSU is located in the forward cockpit area. The TSU is used to provide the gunner visual contact with a target and guidance signals to the TOW missile (Figure 1-35).

1.3.6.4 Sight Hand Control (SHC). The SHC contains the track control stick, the ACQ/TRK/STOW switch, the PHS ACQ switch, and the CONST OVRD switch. AZ BAL and EL BAL adjustments are provided for organizational level maintenance personnel. The SHC is located in the forward cockpit area easily accessible to the gunner's right hand. The SHC positions the TSU in different modes, dependent on switch positions. (Figure 1-36).

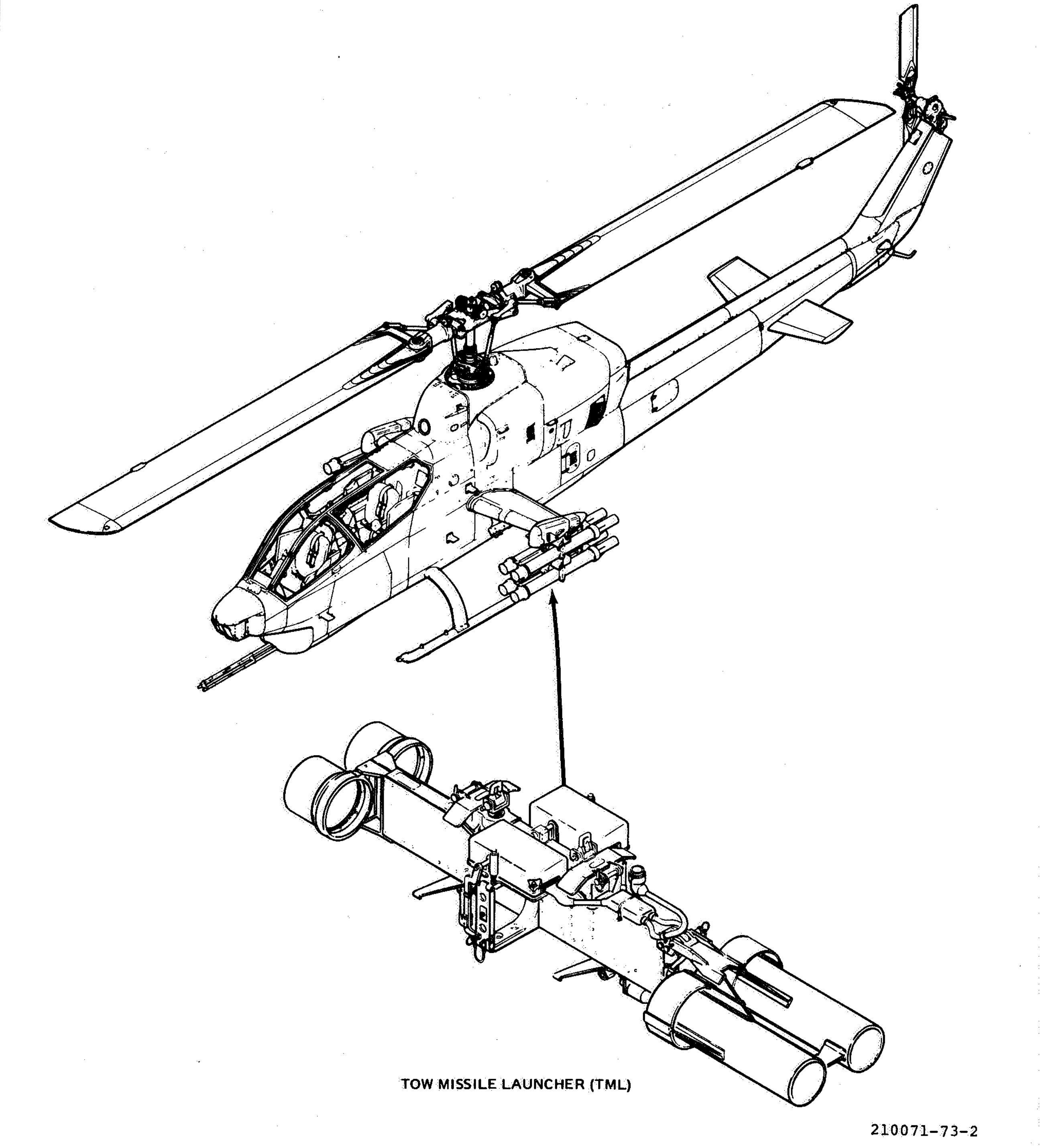
1.3.6.5 TOW Missile Launcher (TML). The TML provides support for up to eight TOW missiles, four on each side of the helicopter, two per launcher. The TML provides electrical isolation of the TOW missile from the TMS until trigger actuation and then provides electrical interface between selected TOW missile and TMS (Figure 1-37).



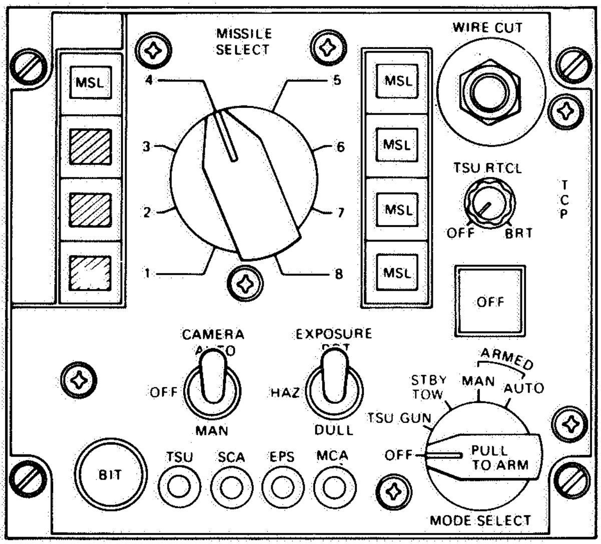
T Figure 1-31. Smoke Grenade Release Diagram



T Figure 1-32. TOW Missile System Components (Sheet 1 of 2)



T Figure 1-32. TOW Missile System Components (Sheet 2 of 2)



LOCATION: GUNNER INSTRUMENT PANEL

NOMENCLATURE		FUNCTION
MODE SELECT Switch	**OFF**	— **Deactivates TSU and TMS circuits.**
	TSU/ GUN	— **Permits gunner to fire turret and perform target acquisition, pilot to fire smoke/wing stores (not TOW) and perform target acquisition.**
	STBY TOW	— **Permits gunner to control TMS/ perform target acquisition, pilot to fire turret and perform target acquisition. Activates built-in-test (BIT) when SHC switch is in STOW, power missile status indicators.**
	ARMED— MAN	**Permits gunner to fire TOW (manually selected) and perform target acquisition, pilot to fire turret, and perform target acquisition.**
	ARMED— AUTO	**Same as MAN except missile is automatically selected.**

NOMENCLATURE		FUNCTION
TSU/SCA/ EPS/MCA Unit Fail Indicators	**Black Flag**	— **Indicates unit operation during performance of built-in-test.**
	White Flag	— **Indicates unit failure during performance of built-in-test**
	Note	— **Only EPS indicates failure during performance, built-in-test, or nonperformance.**
BIT Switch	**Press**	— **Performs manual built-in-test.**
CAMERA Switch	**OFF**	— **Deactivates camera circuit.**
	MAN	— **Permits continuous operation of camera.**
	AUTO	— **Permits operation of camera when LHG TRIGGER is pressed until missile command wire is cut.**
EXPOSURE Switch	**BRT**	— **Permits camera to adapt to bright conditions.**
	HAZ	— **Permits camera to adapt to haze conditions.**
	DUL	— **Permits camera to adapt to dull conditions.**
OFF/PWR ON/ ARMED/TEST System Status Annunciator	**OFF**	— **Indicates MODE SELECT switch in OFF position.**
	PWR ON	— **Indicates MODE SELECT switch in TSU/GUN or STBY TOW position.**
	ARMED	— **Indicates MODE SELECT switch in ARMED position.**
	TEST	— **Indicates built-in-test is being performed.**
TSU RTCL Switch	**OFF**	— **Deactivates the TSU reticle circuit.**
	Turn	— **Varies intensity of TSU reticle lights.**
WIRE CUT Switch	**PRESS**	— **Permits gunner to manually cut missile command wire.**
MSL/Barberpole Missile Status Indicators	**MSL**	— **Indicates missile is present in a specific location of launcher.**
	Barberpole	— **Indicates missile is not present in a specific location of launcher.**
MISSILE SELECT Switch	**1/2/3/4/ 5/6/7/8**	— **Indicates missile selected (manual or automatic) for firing.**

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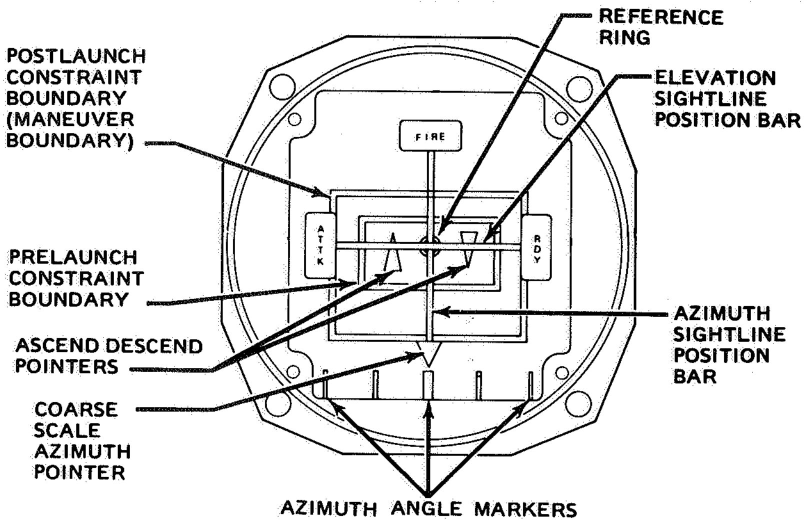
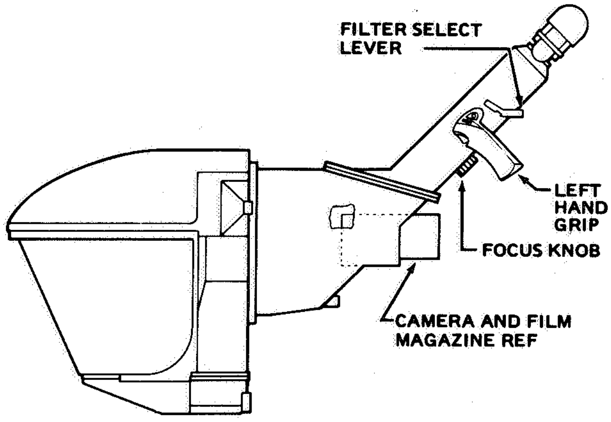
T Figure 1-33. Gunner TOW Control Panel (TCP)


REFERENCE RING
POSTLAUNCH CONSTRAINT BOUNDARY (MANEUVER BOUNDARY)
ELEVATION SIGHTLINE POSITION BAR
FIRE
ATTK
RDY
PRELAUNCH CONSTRAINT BOUNDARY
ASCEND DESCEND POINTERS
AZIMUTH SIGHTLINE POSITION BAR
COARSE SCALE AZIMUTH POINTER
AZIMUTH ANGLE MARKERS

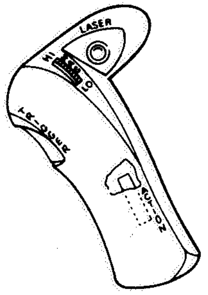
LOCATION: BASE OF PILOT FIXED SIGHT

NOMENCLATURE		FUNCTION
ATTK Annunciator	ON	— Indicates TCP MODE SELECT switch in ARMED position and ACTION switch depressed.
RDY Annunciator	ON	— Indicates pilot has achieved prelaunch constraints.
FIRE Annunciator	ON	— Indicates trigger has been pulled.
Reference Ring (Fixed)		— Represents helicopter reference axis.
Prelaunch Constraint Boundary (Fixed)		— Represents boundary within which the pilot must keep the sightline position bars prior to and during TOW launch. The boundary represents ± 2.4° azimuth and ± 6° elevation.
Postlaunch Constraint Boundary (Fixed)		— Represents boundary within which the pilot must keep the sightline position bars after TOW launch and until wire cut or missile impact.
Elevation/ Azimuth Sightline Position Bars (Moveable)		— Indicates TSU elevation and azimuth angles with respect to helicopter reference axis (reference ring) and constraint boundaries.
Ascend Descend Pointers (Indicator)	ON	— Indicates amount of change required in nose-up or nose-down attitude to meet prelaunch constraints.
	OFF	— Indicates helicopter nose attitude and line-of-sight rate are compatible.
Azimuth Angle Markers (Fixed)		— Represents TSU ± 110° azimuth limits.
Course Scale Azimuth Pointer (Moveable)		— Indicates TSU azimuth angle on the azimuth angle markers.

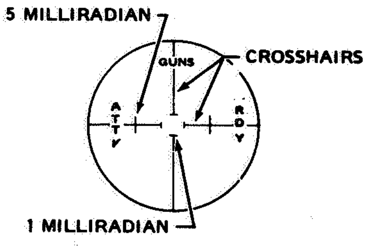
T Figure 1-34. Pilot Steering Indicator (PSI) 210071-37



TELESCOPIC SIGHT UNIT
LOCATION: GUNNER STATION



LEFT HAND GRIP



VIEW OF RETICLE

NOMENCLATURE		FUNCTION
Left Hand Grip Switches MAG Switch	LO	— Magnifies target two times.
	HI	— Magnifies target 13 times.
TRIGGER Switch	Press	— Fires TOW in first or second detent.
		— Fires turret 16 ± 4 round burst in first detent.
		— Fires turret continuously in second detent.
ACTION Switch	Press	— Activates TOW launchers.
		— Slaves turret to TSU or gunner HS.
LASER Switch		— Inoperative.
TSU Reticle GUNS Indicator	Flash	— Indicates TCP MODE SELECT switch in TSU/GUN and turret not aligned with TSU.
	Steady	— Indicates TCP MODE SELECT switch in TSU/GUN and turret aligned with TSU.
ATTK Indicator	ON	— Indicates TCP MODE SELECT switch in ARMED and ACTION switch depressed.
RDY Indicator	ON	— Indicates pilot has achieved prelaunch constraints for TOW firing.
Filter Select Lever	Move	— Selects filters of different light intensities.
Focus Knob	Turn	— Focus the target image.

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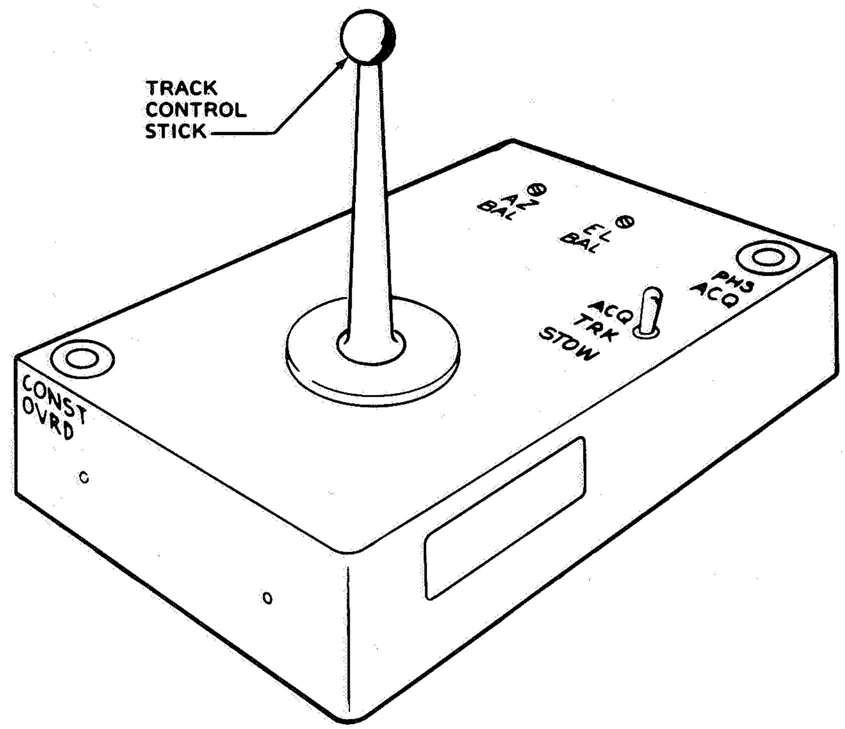
T Figure 1-35. Gunner Telescopic Sight Unit (TSU)



LOCATION: GUNNER INSTRUMENT PANEL

NOMENCLATURE	FUNCTION	
Track Control Stick	Move	— Positions TSU in aximuth and elevation.
ACQ/TRK/STOW Switch	ACQ	— Slaves TSU to gunner HS for target acquisition.
	TRK	— Permits track control stick to position TSU.
	STOW	— Stows TSU dead-ahead.
PHS ACQ Switch	Press	— Slaves TSU to pilot HS for target acquisition.
EL BAL Screw		— Used during maintenance.
AZ BAL Screw		— Used during maintenance.
CONST OVRD Switch	Press	— Permits TOW firing when helicopter is not aligned within the prelaunch constraint boundary.

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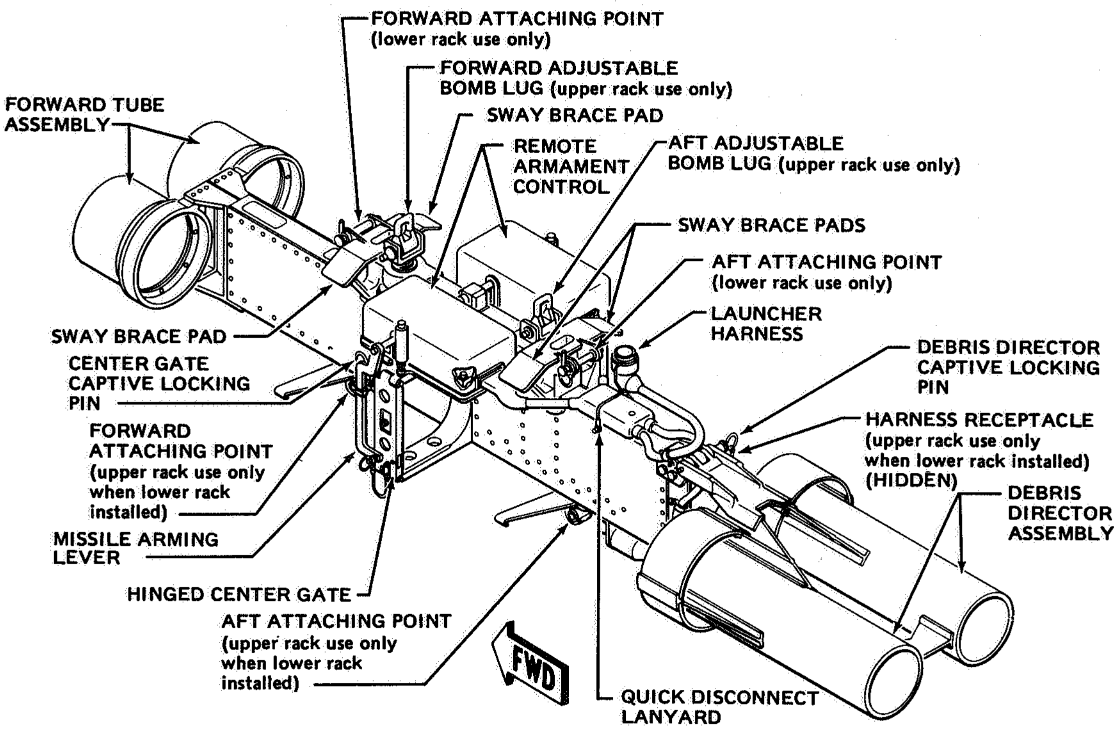
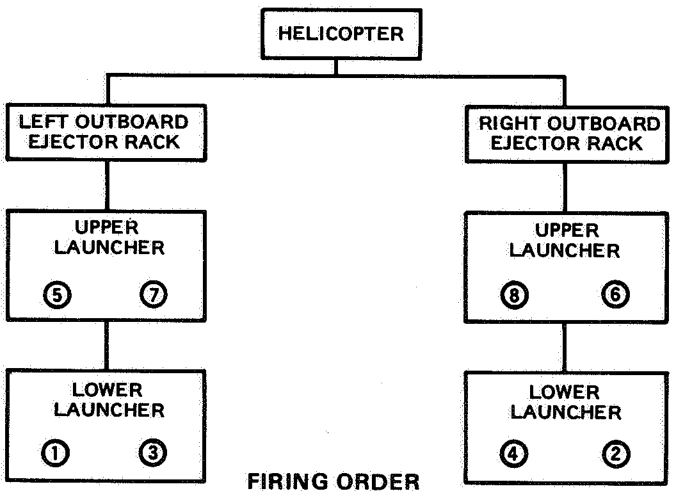
T Figure 1-36. Gunner Sight Hand Control (SHC)


FORWARD ATTACHING POINT (lower rack use only)
FORWARD ADJUSTABLE BOMB LUG (upper rack use only)
SWAY BRACE PAD
FORWARD TUBE ASSEMBLY
REMOTE ARMAMENT CONTROL
AFT ADJUSTABLE BOMB LUG (upper rack use only)
SWAY BRACE PADS
AFT ATTACHING POINT (lower rack use only)
LAUNCHER HARNESS
SWAY BRACE PAD
CENTER GATE CAPTIVE LOCKING PIN
DEBRIS DIRECTOR CAPTIVE LOCKING PIN
FORWARD ATTACHING POINT (upper rack use only when lower rack installed)
HARNESS RECEPTACLE (upper rack use only when lower rack installed) (HIDDEN)
DEBRIS DIRECTOR ASSEMBLY
MISSILE ARMING LEVER
HINGED CENTER GATE
AFT ATTACHING POINT (upper rack use only when lower rack installed)
FWD
QUICK DISCONNECT LANYARD

LAUNCHER



FIRING ORDER

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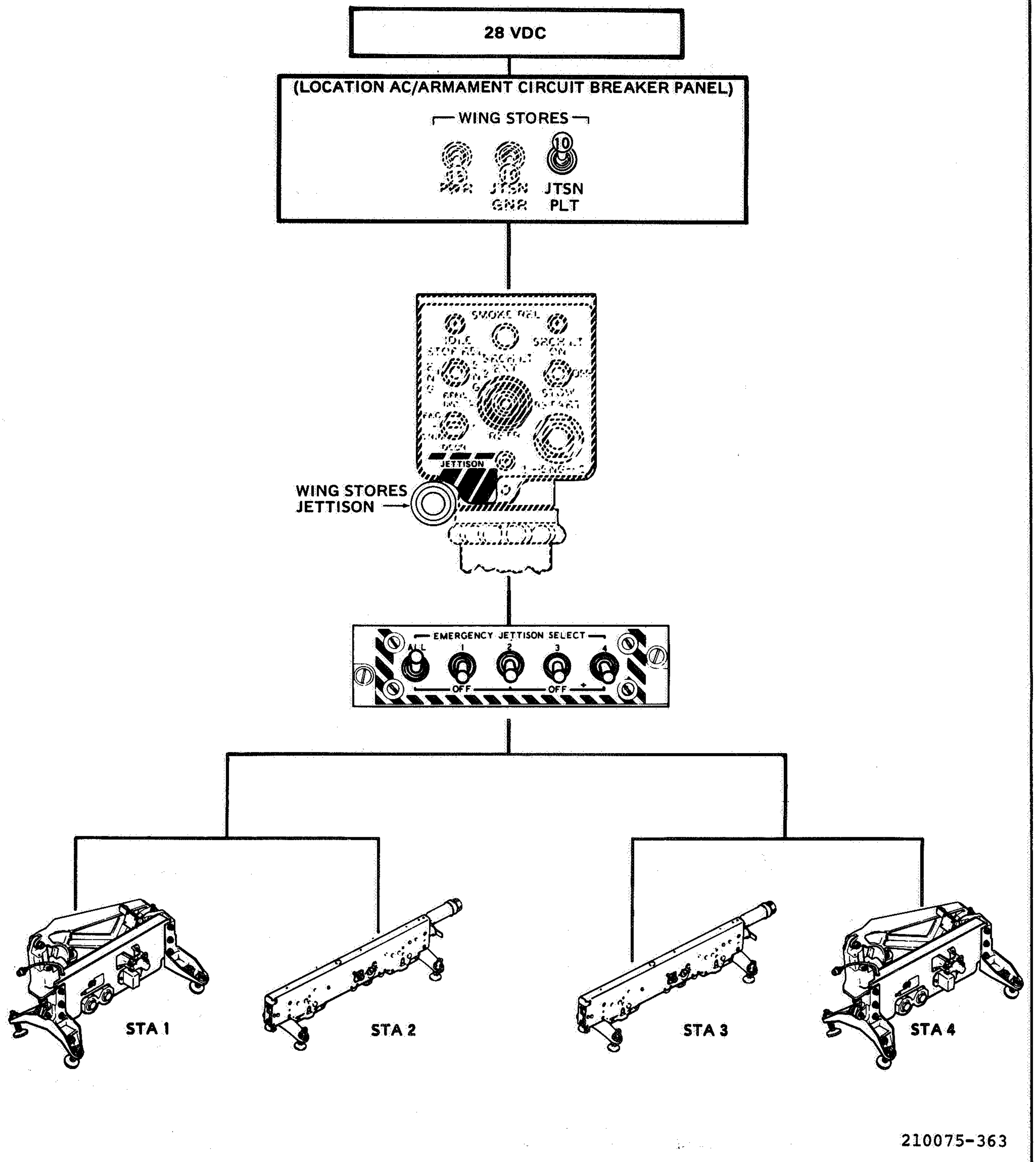
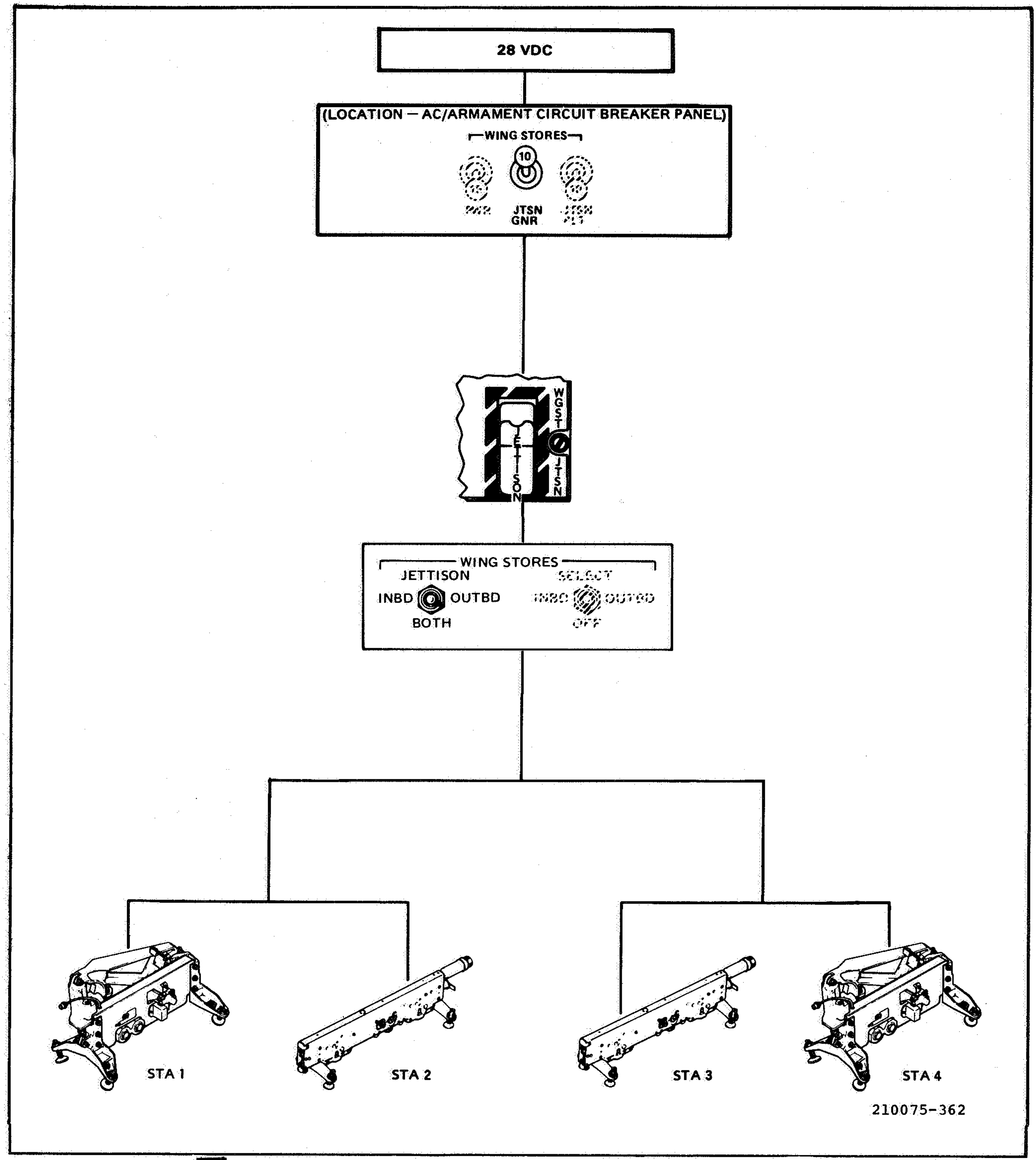
Figure 1-37. TOW Missile Launcher

1.3.7 Wing Stores Jettison System. The pilot jettison system (Figures 1-38 and 1-39) consists of an EMERGENCY JETTISON SELECT panel located on the left side of the instrument panel (Figure 1-40) and a JETTISON button located on the lower side of the collective pitch control switch box. The gunner jettison system consists of a WING STORES JETTISON switch located on the gunner armament control panel and guarded WG ST JTSN switch located on the miscellaneous control panel (Figure 1-41). Logic circuitry provides an automatic time delay of 700 ± 100 milliseconds between outboard and inboard releases, thus preventing collision of adjacent weapons/stores. The inboard stations eject their respective weapons/stores at a 45° angle outboard to clear the skid landing gear, and the outboard stations eject their respective weapons/stores vertically.

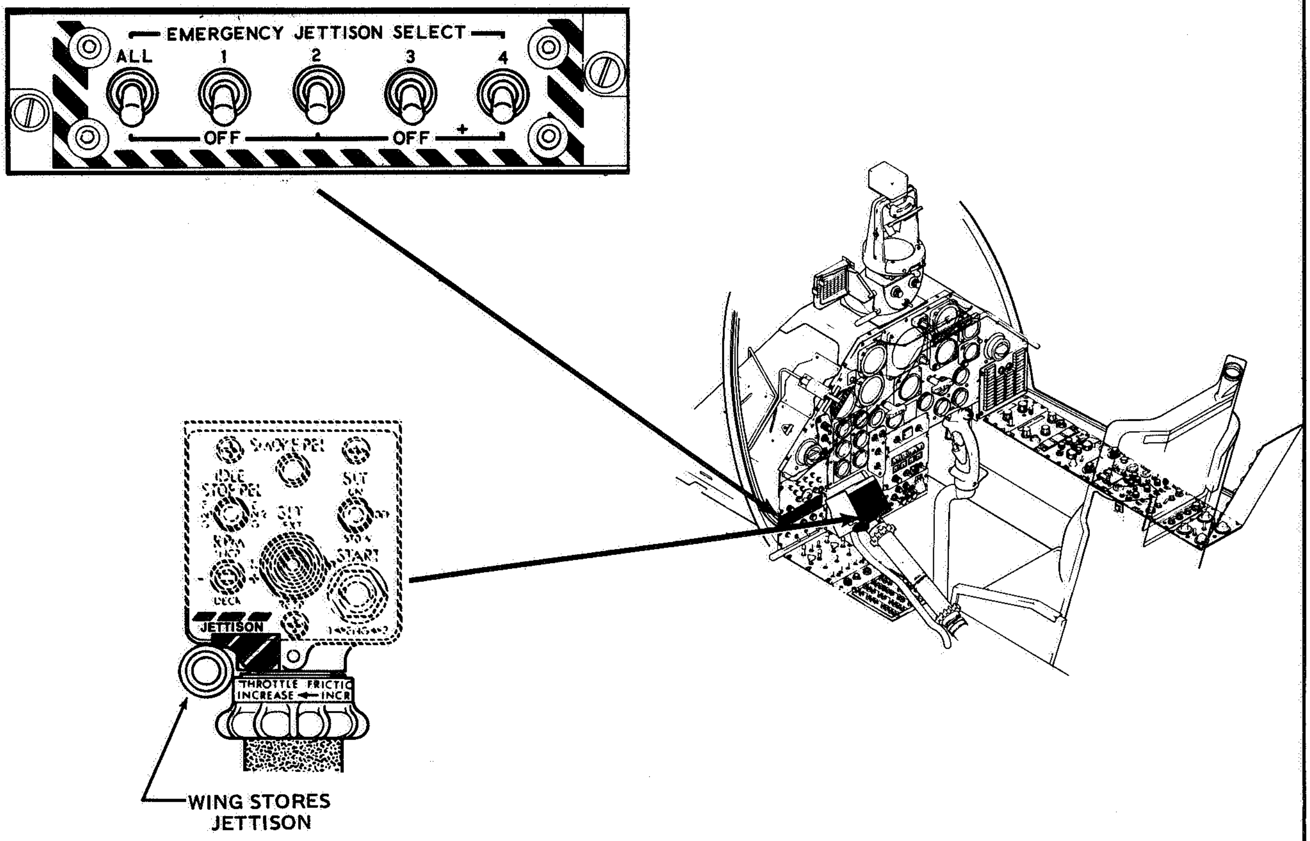
1.3.7.1 Jettison Select Switches. The pilot EMERGENCY JETTISON SELECT panel utilizes five toggle switches to select the wing stations from which weapons/stores are to be jettisoned. Four numbered switches control corresponding wing stations. These switches may be selected individually or in any combination desired to jettison weapons/stores selectively as required. The switch labeled ALL selects all four wing stations to jettison their weapons/stores with one release pulse. The gunner can jettison wing weapons/stores selectively in pairs, inboard or outboard, or both inboard and outboard. Wing weapons/stores to be jettisoned can be selected by placing the WING STORES JETTISON switch to INBD, BOTH, or OUTBD position. After the selection is made, release is initiated by activating the WG ST JTSN switch.



T Figure 1-38. Pilot Emergency Jettison System Diagram



T Figure 1-39. Gunner Emergency Jettison System Diagram



ITEM	FUNCTION	
ALL switch	ALL	— Permits pilot to jettison all wing stores.
1, 2, 3, and 4 switches	1, 2, 3, and 4	— Permits pilot to jettison desired wing stores.
WING STORES JETTISON switch		— Jettisons wing stores in accordance with EMERGENCY JETTISON SELECT panel switch setting.

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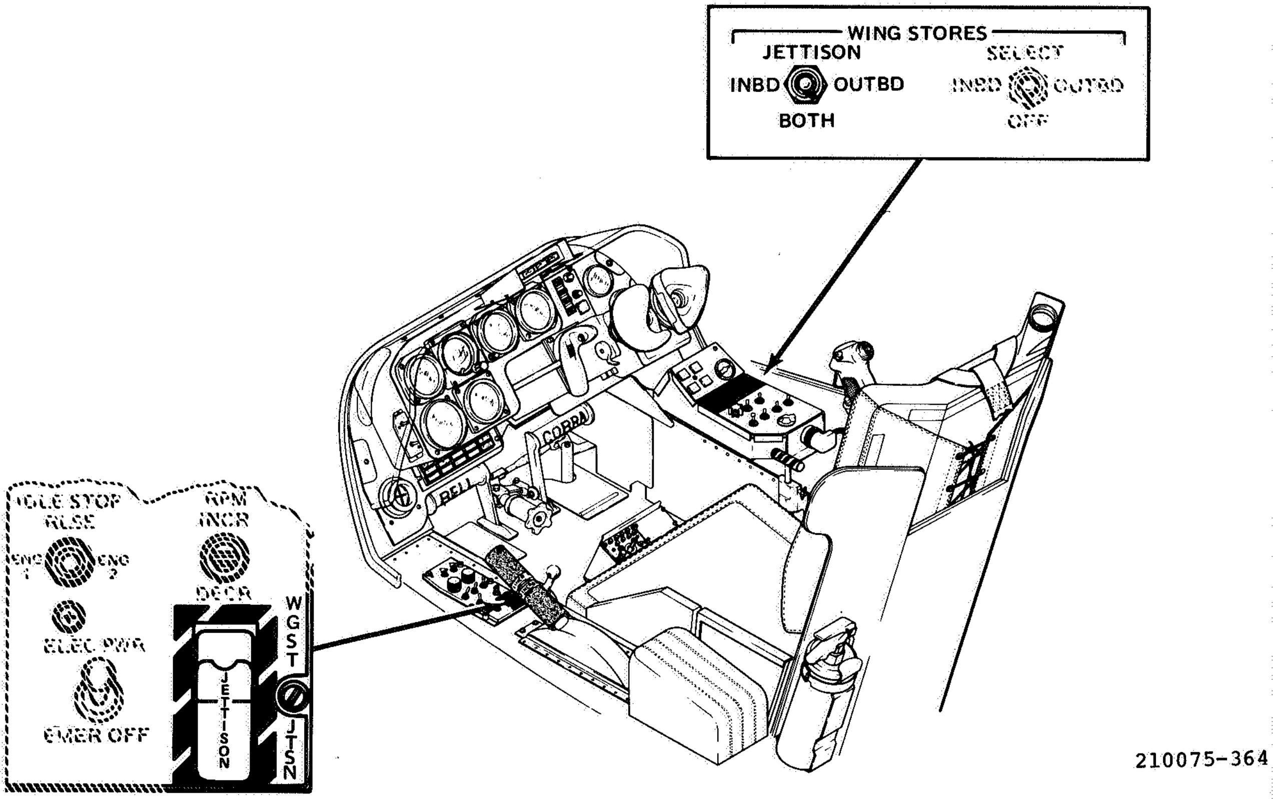
T Figure 1-40. Pilot Wing Stores Jettison Controls



T Figure 1-41. Gunner Wing Stores Jettison Controls

CHAPTER 2

Weapons Delivery

2.1 INTRODUCTION

The attack helicopter is an essential element in the modern battlefield. To maximize the effectiveness of the attack helicopter, aircrews must be familiar with the system used, the aiming data provided, and the methods of correcting for factors which cause impact errors.

2.2 WEAPONS DELIVERY TECHNIQUES

The techniques to be employed in delivery of air-to-surface weapons from an attack helicopter will be selected by the flight leader based on the tactical factors and conditions existing on the battlefield. With increased threats at high altitudes, low altitude terrain flight firing techniques have become more important. Attack helicopter flights may engage a target with diving fire, level (running) fire, hover fire, or by use of nap-of-the-Earth extended range (NOE/extended range) fire. Due to the nature of the turret and the size munitions, use of the turret in a nonstowed configuration is envisioned mainly as a defensive tactic and as such will not be treated here.

2.2.1 Diving Fire. Diving fire is delivered on a target while the helicopter is in forward, descending flight. Sight setting data provided in Appendix H is for a helicopter in a straight path unaccelerating dive. Errors due to firing in a nontrimmed state are treated in paragraph 2.3.2.4.4 under relative wind effects. Diving fire is the mose accurate type of fire.

2.2.1.1 Cone of Fire/Dispersion Pattern. For any large number of rounds fired, it is possible to draw a cone within which the trajectories of all the rounds will fall. Since the dispersion is considered equal throughout the cone, the mean trajectory is found anywhere along the length of the center of this cone. If a plane surface intersects the cone perpendicular to the mean trajectory, the dispersion pattern on the plane surface will be circular (Figure 2-1). When the impacting surface is perpendicular to the mean trajectory, the normal impact pattern is equally distributed about the center of impact. However, as an angle of the impact surface changes from the perpendicular to oblique, the dispersion pattern becomes elongated; the same number of rounds are the same distance long as short. The circular error probable (CEP) is the radius of a circle within which half of the rounds are expected to fall. In a normal distribution pattern, a distance of four CEPs in range and one CEP in deflection, on either side of the center of impact, will contain virtually all the rounds. However, since a difference in the angle of attack and the resulting angle of impact greatly affects the dispersion pattern, this is not altogether correct. The shallower the angle of impact, the more elongated the dispersion pattern becomes, although the ratio of 4:1 holds true for practical purposes. (Figure 2-2.)

2.2.1.2 Range. Range should be expressed as slant range. Range is expressed in meters and may be measured graphically, electronically, or estimated. The range of any projectile is a function of the muzzle velocity (or terminal velocity for rockets) and the elevation of the bore. Elevation for helicopter gunnery is measured from the line of sight, and may be either positive (elevation) or negative (depression). (Figure 2-3.)

2.2.1.3 Speed of the Helicopter. When closing with the target, helicopter speed requires a continual estimation of range. As helicopter

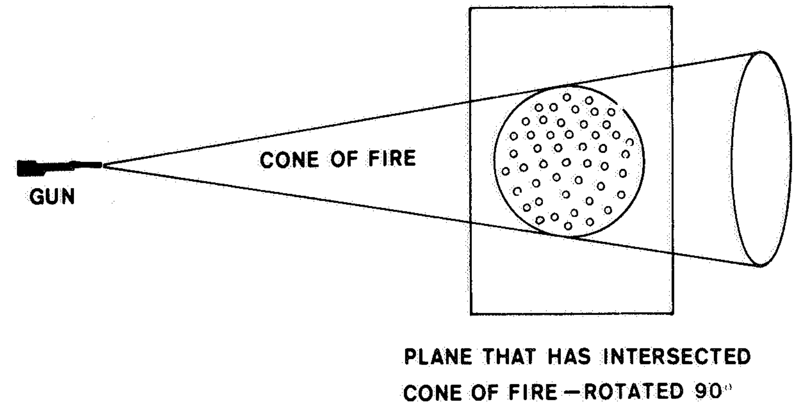


Figure 2-1. Cone of Fire

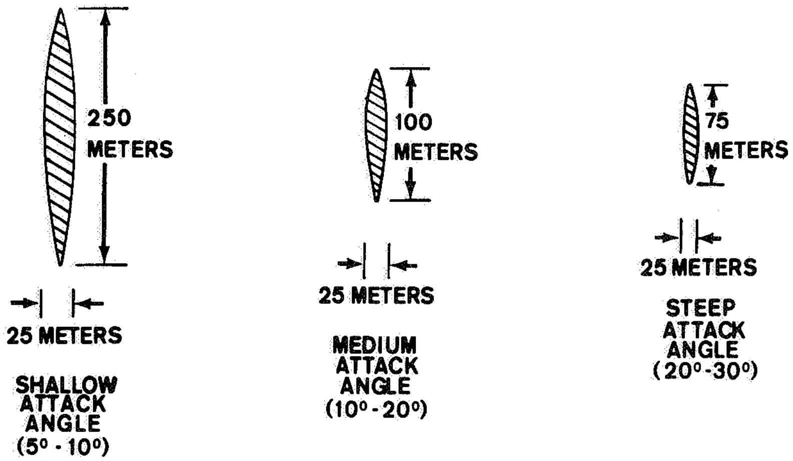

250 METERS
25 METERS
SHALLOW ATTACK ANGLE (5° - 10°)
100 METERS
25 METERS
MEDIUM ATTACK ANGLE (10° - 20°)
75 METERS
25 METERS
STEEP ATTACK ANGLE (20°-30°)

Figure 2-2. Dispersion Pattern

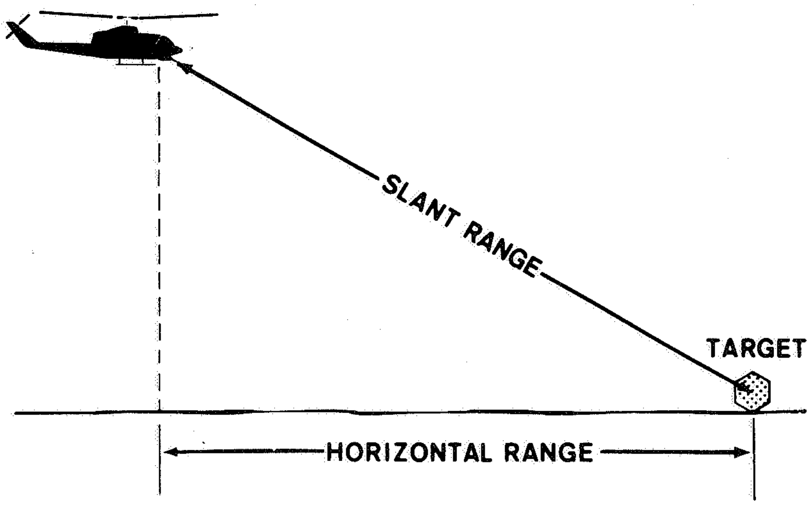


Figure 2-3. Slant Range

speed increases, deflection shots must have the correct lead factor applied to correct for trajectory shift.

2.2.1.4 Sight Picture. Because of the rapidly changing position of the helicopter, application of the correct sight picture is critical.

2.2.1.5 Pattern of Impact. Distribution is the pattern of impact (beaten zone) in the target area. When possible, the attack helicopter should engage the target with enfilade fire. This means that the long axis of the beaten zone coincides with the long axis of the target. The size and shape of the beaten zone depends on the attack angle of the weapon and the surface configuration.

2.2.1.6 Turning Error. Firing while in a bank affects both fixed and flexible weapons. To compensate for ballistic factors, the boreline axis of all weapons systems is elevated above the horizontal. If the weapon is fired while the helicopter is in a bank, this elevation becomes deflection. Firing results in rounds impacting short and inside the turn. To compensate for turning error, it is necessary to aim high and opposite to the direction of the bank. In addition, a range estimation and power setting adjustment are necessary. Since this complicated technique greatly decreases accuracy, it should be attempted in emergency situations only (Figure 2-4).

2.2.1.7 Sighting Techniques. Because of maneuverability of the helicopter and the wide variety of target situations, the helicopter crew must have a thorough knowledge of weapons systems' capabilities and limitations. The techniques of engaging targets depends upon the weapons systems being used. Basically, these systems can be broken into two groups: fixed systems (i.e., rockets, bombs and fixed/stowed guns) and flexible guns.

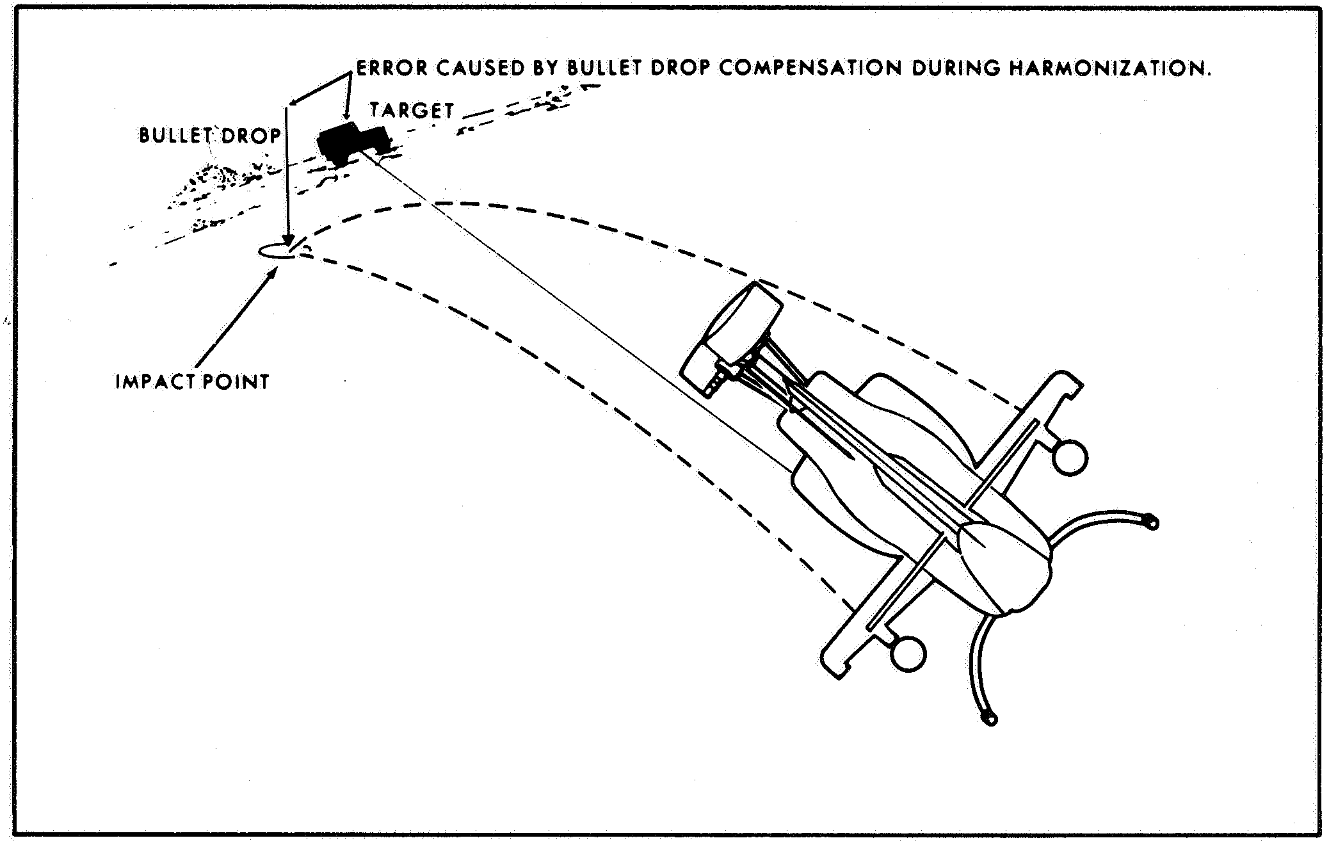

ERROR CAUSED BY BULLET DROP COMPENSATION DURING HARMONIZATION.
TARGET
BULLET DROP
IMPACT POINT

Figure 2-4. Turning Error

2.2.1.7.1 Special Considerations. Parallax is the apparent difference in location of a single object as seen when observed from two different points. It is caused by a misalignment of the pilot's sight lens and can result in serious errors in gunnery; for a gunner, parallax is present in a reflex infinity sight when a change in his head position moves the pipper from the target. The sight is free of parallax error; the pipper will remain on the aiming point regardless of the gunner's head position.

It is advisable to sight with both eyes when adjusting tracer fire since the gunner has better depth perception and is better able to acquire and adjust the tracer fire onto the target. This is especially desirable when firing at targets greater or shorter in range than the boresight range.

Night vertigo is of primary importance to attack helicopter crewmembers. Because of the steep dive angles and sharp turns incurred in helicopter attacks and the possible resulting loss of equilibrium, it is normally advisable for either the pilot or copilot to monitor the instruments during target attacks at night. In this manner, the symptoms of vertigo are easily recognized and positive control of the helicopter can be assumed by the crewmember not affected.

Target fixation is a condition found most often in aviators intent on destroying a given target. It results in the loss of appreciation for speed, rate of closure, altitude, and other external stimuli. This condition can normally be avoided by consciously avoiding fixation on a single point, even during target attacks.

2.2.1.7.2 Boresighting. Boresighting is the process by which the optical axes of the sight are made parallel (vertically and horizontally) to the boreline axis of the weapon. Depending upon availability of tools, type of weapon, etc., two methods are prescribed for boresighting each subsystem. These methods are distant aiming point and the parallel line. In the distant aiming point method, a common point is selected at a relatively great distance (preferably infinity) to which the longitudinal axis of the helicopter, the sight, and the weapons are aligned. If the aiming point is selected at less than infinity, the axis of each weapon will converge at the aiming point. In the parallel line method, a sighting board is aligned with the helicopter. The sight and weapons are aligned with measured points on the sighting board. In this method, the axes of the weapons do not converge.

2.2.1.8 Sighting/Tracking Techniques

2.2.1.8.1 Fixed Systems. The techniques required to fire aerial rockets are more restrictive than those for firing fixed/stowed guns; therefore, this discussion will be limited to rocketry. The same techniques will ensure accurate fire with fixed/stowed guns. Airborne rockets are affected by many variables (such as crosswind, relative wind, and flight coordination) which can be compensated for. Because of these variables and their adverse affect on rocket accuracy, two methods of sight will be discussed.

The pipper intersection method requires that a release altitude, airspeed, and range be determined prior to release. From these predetermined conditions, a computed sight setting is obtained from the sight angle tables. This method is normally used on preplanned missions and against targets where reaction time is not a factor.

The combat sight method is the most widely used and gives the desired accuracy and timeliness over the widest variety of mission profiles. It requires very little mathematical or manual manipulation, which is distracting during target attack; and, by using a single sight setting, it allows engagement of targets over widely varying ranges without adjustment of the sight. It does require that offset correction (Kentucky Windage) be applied for both range and wind conditions. The requirements for using the combat sight method are that:

1. The helicopter be in coordinated flight
2. The range be estimated within 100 meters
3. The proper amount of offset correction be applied.

2.2.1.8.2 Flexible System. The sighting techniques for flexible weapons systems are similar to those for fixed systems. Specific weapons, sights, and sight displays will differ with weapons having high and low muzzle velocity.

2.2.1.8.3 High Muzzle Velocity. Weapons with a high muzzle velocity have a relatively flat trajectory and are not affected by those ballistic factors associated with flexible weapons as much as low muzzle velocity weapons. The following procedure applies:

Place the pipper on the target. Fire and observe tracer impact. Adjust weapons so tracers impact on the target. Because of the high volume of fire and the relatively simple sighting techniques, fire from this type of weapon is relatively accurate.

2.2.1.9 Establishing the Combat Sight. To better understand why the combat sight method of engaging targets is more widely used than other methods, it is helpful to understand the procedure for establishing the combat sight.

Following is an example using the combat sight which is equally applicable to any fixed fire system.

1. Boresight the system in accordance with the appropriate armament subsystem section.

2. Select a target at a slant range equal to one-half the maximum effective range of the weapon; however, the selected range will be that range from which the majority of all targets are engaged. This selected range may be made according to individual preference or unit SOP.

3. At a tactical altitude and airspeed and with the pipper on the target, fire one round, note the impact of the round, and rotate the elevation-depression ring to put the pipper on the ground impact.

4. Repeat step 3 until the rounds are consistently hitting on the pipper. Usually three rounds will be sufficient to obtain the combat sight setting. This setting may be established at any range. Midrange allows the widest possible latitude for engaging targets. Using this method, targets may be engaged from the minimum safe slant range to the maximum effective range.

Note

> The combat setting for guns is normally accomplished at slightly less than maximum effective range. Targets beyond maximum effectve range may be engaged with an acceptable dispersion pattern. This is accomplished by adjusting the fire so that tracer burnout appears to occur just above the target.

2.2.1.10 Using the Combat Sight Setting. At the altitude and airspeed chosen for obtaining the setting, the rounds will impact at the pipper at the selected range. Therefore, it is necessary to use this altitude, airspeed, and range, or to compensate for any changes. Changes in range are accomplished by aiming 4-mils high for each 100 meters beyond the range chosen for the setting, and 4-mils low for each 100 meters less. If the combat sight setting is made at 1250 meters, the proper setting required to engage a target at 2500 meters, the proper setting required to engage a target at 2500 meters is to hold the pipper at 50 mils (4 X 12.5 = 50) above the target. If the target is at 300 meters, hold the pipper at 38 mils (4 X 9.5 = 38) below the target.)

Once an entry altitude and airspeed have been selected, a constant power setting must be maintained and the same selected firing altitude, dive angle, and airspeed used in each pass at the target. For example, if the setting were obtained using 50-percent torque in the helicopter, this setting would result in nearly the same trajectory each time if the helicopter weight remains relatively constant.

Considering the factors in the preceding paragraphs, one way to use the combat sight setting is to:

1. Check the power setting and helicopter trim and adjust.

2. Initiate the roll-in on the target run.

3. Estimate the slant range to the target and apply the compensation factor.

4. Obtain the proper sight picture by flying the helicopter, using only the cyclic control stick and rudders to maintain balanced flight.

5. While the helicopter is in its most stable flight, fire as soon as the proper sight picture is obtained. The helicopter becomes more unstable as the dive progresses and airspeed builds up.

6. Use burst on target for subsequent adjustments.

2.2.1.11 Range Estimation. To effectively employ the attack helicopter, the aircrew must be capable of determining the range to the target. Inaccurate range estimation results in rounds missing the target and alerts the enemy to a pending attack, thus reducing the effectiveness of surprise. The key to knowing how to accurately estimate range is training. The methods of determing range are estimation by eye, sight mil values, tracer burnout, maps and photomaps, and electronic devices.

2.2.1.11.1 Estimation by Eye. The most common method used for determining range is estimation by eye. Normally this method is most accurate when the range is compared to known ranges; i.e., the number of 100-meter segments that are in the range. While this method is the most rapid, some reasons for its inherent inaccuracy are:

1. Nature of the target

— A target in contrast to its background appears closer.

— A target that blends with its background appears farther.

— A target that is partially hidden appears more distant.

2. Nature of the terrain

— Over smooth terrain, the eye tends to underestimate the range.

— Over rough terrain, the eye tends to overestimate the range.

3. Visibility

— A target seen in full sunlight appears closer than one observed through haze or fog.

— When the sun is behind the target, the target appears more distant. When the sun is behind the observer, the target appears nearer.

2.2.1.11.2 Sight Mil Values. Because of sight vibration caused by aircraft flight, reading the mil value of target width in the sight is difficult. However, if this value can be found and the actual target width is known, the mil value for target width can easily be converted to the range. At a range of 1000 meters, 1 mil equals 1 meter; therefore, if target width is known, range can be found by using the following formula:

$$R = \frac{W \times 1000}{M}$$

WERM

R = (Meters)
W = Known Target Width (Meters)
M = Mil Value of Target Width (Mils)

For example, a tank known to be 15 meters long covers 20 mils of reticle width.

$$R = \frac{15 \text{ meters} \times 1000}{20 \text{ Mils}} = 750 \text{ meters}$$

2.2.1.11.3 Tracer Burnout. The M50-series 20-mm round of tracer ammunition burns out at approximately 1500 to 2000 meters, which corresponds to the maximum effective range. The gunner's range estimate is based on this observation. For example, the gunner fires a burst of tracer ammunition from the gun that burns out halfway to the target. Thus, he estimates that the range to the target is twice the distance of estimated tracer burn.

2.2.1.11.4 Maps and Photomaps. Prior to and during the mission, ranges from prominent terrain features to the target area may be determined from maps and photomaps. This permits comparison of actual ranges with ranges estimated by the eye and is very useful in teaching aviators to visually estimate ranges correctly. This is the primary method of determining ranges when operating in a high-threat environment and allows an aircrew to accurately determine the range to the target without exposing the helicopter to the enemy. The use of maps and photomaps at night is more restrictive because of the limited range at which terrain features can be identified.

2.2.1.11.5 Electronic Devices. The most accurate means of determining range to the target is by use of electronic devices. A newer generation of attack helicopters may even be equipped with laser range finders. This equipment will provide the aircrew with fast, accurate range information which will improve the first-round-hit capability for the aircrew of an attack helicopter.

2.2.1.11.6 Range Estimation Utilizing the Telescopic Sight Unit (TSU). The TOW missile system provides the gunner with a stabilized telescopic sight with low (LO) which is 2-power, and high (HI) which is 13-power magnification. The gunner can select either power by moving the magnification (MAG) switch on the left handgrip (LHG) of the TSU. When the LO MAG position is selected, a 28° field of view can be seen by the gunner. Movement of the telescopic turret (bucket) is accomplished by movement of the track control stick on the sight hand control (SHC). The bucket containing the optics can be moved in azimuth 110° left and right of the helicopter centerline, 30° elevation, and 60° depression. The sight will slew at a rate of 100° per second both in elevation and azimuth when in the LO MAG position. In the HI MAG positon, the sight will slew at a rate of 3° per second in elevation and azimuth.

When operating in the LO MAG mode, a circle is displayed in the sight reticle that represents the field of view for high power magnification (HI MAG). It is used by the gunner to determine when he can transition to high power without losing contact with the target or in which direction and how far he must search to acquire the target after switching to HI MAG. When operating in the HI MAG mode, a 4.6° field of view can be seen by the gunner. The elevation and azimuth limits of the optic are the same as for the LO MAG mode of operation. The reticle image displayed in the TSU consists of an outer circle with a vertical and horizontal crosshair. Positioned along the horizontal crosshair is a series of vertical marks. These marks are provided to aid the gunner in estimating range to the target. The distance between the outer vertical marks is 10 mils with 2 mils separating the inner marks. At a distance of 3400 meters, the T-62 tank will fit lengthwise within the 2 mil opening. At the center of the sight reticle is an opening which is 0.4-mil wide. This area will display a 54-inch square at the maximum range (3750 meters) of the missile and is the aiming point for the gunner when sighting targets. Refer to Figure 2-5 for TSU reticles.

For training purposes, it is recommended that a range estimation facility be set up which has realistic target sizes and range flags marking different ranges from the target. This would provide realistic training for all pilots and gunners.

2.2.1.12 Flight Techniques. Before accuracy with aerial-fired weapons can be expected, the aviator must be able to fly the helicopter without actually concentrating on the art of flying. However, to assure weapons accuracy, coordinated flight must be maintained by smooth control pressures.

2.2.1.12.1 Coordination. Coordinated flight is especially important in aerial rocketry. An out-of-trim condition creates unacceptable dispersion in rocket fire. Emphasis must be placed on flying the helicopter to the proper sight picture instead of using uncoordinated flight to obtain the picture. A common tendency is cross-control using the rudder pedals to get the proper sight picture.

2.2.1.12.2. Control Touch. Control touch affects both fixed and flexible firing modes. Since rough and abrupt control movements result in

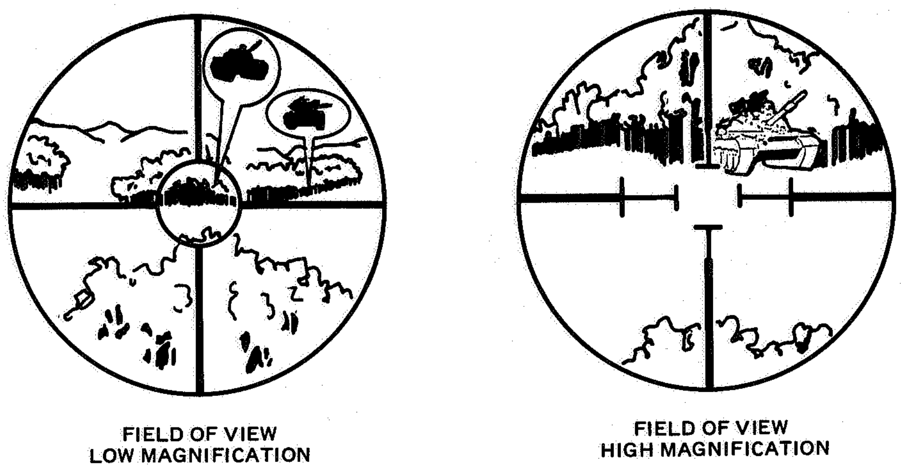


Figure 2-5. TSU Reticles

unacceptable dispersion pattern, smooth control pressures must be applied.

2.2.1.12.3 Spot Weld. For most aviators, the spot weld consists of bracing their right elbow on their right thigh. This braced position allows the proper muscle response for positive smooth control movements and permits the proper sight picture to be obtained in a much shorter time without the unnecessary movements which result in chasing the pipper around the target.

2.2.1.13 Tracking. Tracking (Figure 2-6) can be accomplished by placing the pipper on the target immediately after dive entry or by placing the pipper at the 6 o'clock position on the target and allowing it to move toward the target center. Firing should occur the instant the aircraft arrives at the release altitude, on the dive angle, and with the airspeed for which the sight setting was computed. Airspeed and dive angle control are achieved with relatively less difficulty than solving the problem of tracking to the release point.

When the gunsight pipper is held on the target during the dive, the aircraft flightpath becomes convex and the dive angle increases. The g-load decreases as the dive progresses. Tracking is simplified since the pipper is held on the target until weapon release. Corrections during the run are difficult to apply. This method is known as *curvilinear tracking.*

Straight path tracking occurs when the pipper is initially placed at the 6 o'clock position on the target. The movement of the aircraft causes the pipper to follow a straight line path during the dive. As altitude is decreased, the pipper is allowed to move toward the target center. The g-load becomes slightly less than 1 g. Although the dive angle remains constant, the pipper will constantly move to the 12 o'clock position. Ideally, the aircraft should reach the release altitude on the proper dive angle just as the pipper crosses the intended target.

Normally, a combination of curvilinear and straight path dive tracking is recommended as the method that provides position checks and reduces the variables in the dive. The pipper is initially held a fixed number of mils below the target. At a predetermined altitude, the pipper is allowed to move toward the target so that a straight line flightpath is achieved during the final tracking portion of the dive until release.

2.2.2 Terrain Flight Ordnance Delivery. Because the threat will very often preclude diving fire, terrain flight firing techniques have been developed. This capability will allow attack helicopters to deliver fire on area targets while minimizing their vulnerability.

The two types of terrain flight ordnance delivery are running fire and hover fire. There are also two modes of terrain flight ordnance delivery. The attack helicopter can engage a target using either direct or indirect fire. Direct fire is used to engage targets which are visible to the aircrew. Indirect fire is the engagement of targets at extended range and is used primarily against area targets. Both types of fire (running and hover) can be conducted using the direct or indirect mode.

2.2.3 Running Fire. Running fire is delivered on a target while the helicopter is in level forward flight. It can be delivered from any altitude, provided the slant range to the target is less than or equal to the maximum effective range of the weapon. Running fire delivered from terrain flight altitudes is less vulnerable to enemy air defenses than diving fire. This mode provides fire which is highly effective against troops in the open, but the attack helicopter's vulnerability is increased if the troops are located in terrain offering cover (Figure 2-7).

2.2.3.1 Delivery Techniques — Direct Fire, Rockets. When performing direct running fire, a firing point (Figure 2-8) on the ground must be selected from which the weapons system will be fired. The location of the firing point must provide unobstructed visibility with the target. The distance to the target should be approximately the same as one of the ranges on the sight cards. A procedure used to determine a firing point is to draw one or more arcs at varying ranges using the target as the apex of the arc. Tentative selection of primary and alternate firing points is made by map reconnaissance, and final selection is made during the mission. This procedure can be used for determining firing points for both direct and indirect fire delivery techniques. Determine the mil setting corresponding to the desired range on the sight card and apply the ballistic correlation. The resulting value is placed on the mil scale of the gunsight. Establish a flightpath which will cause the helicopter to overfly the firing point while maintaining the desired direction of fire (Figure 2-9).

The helicopter is aligned with the target when the vertical hairline on the gunsight reticle is centered on the target (Figure 2-10).

Just prior to reaching the firing point, the pilot must apply aft cyclic to raise the nose of the helicopter to position the horizontal hairline on the target. Movement of the cyclic should be continuous application of aft pressure. Abrupt movement of the cyclic reduces the accuracy of the weapons system and will cause an increase in the height of climb during the maneuver. To achieve greater accuracy, a stabilized power setting should be established and maintained throughout the maneuver. Even though the helicopter will climb, slower airspeeds and smoother application of control movements will reduce the amount of climb (Figure 2-11).

When the intersection of the horizontal and vertical hairline (pipper) appears on the target, the weapon system is fired (Figure 2-12).

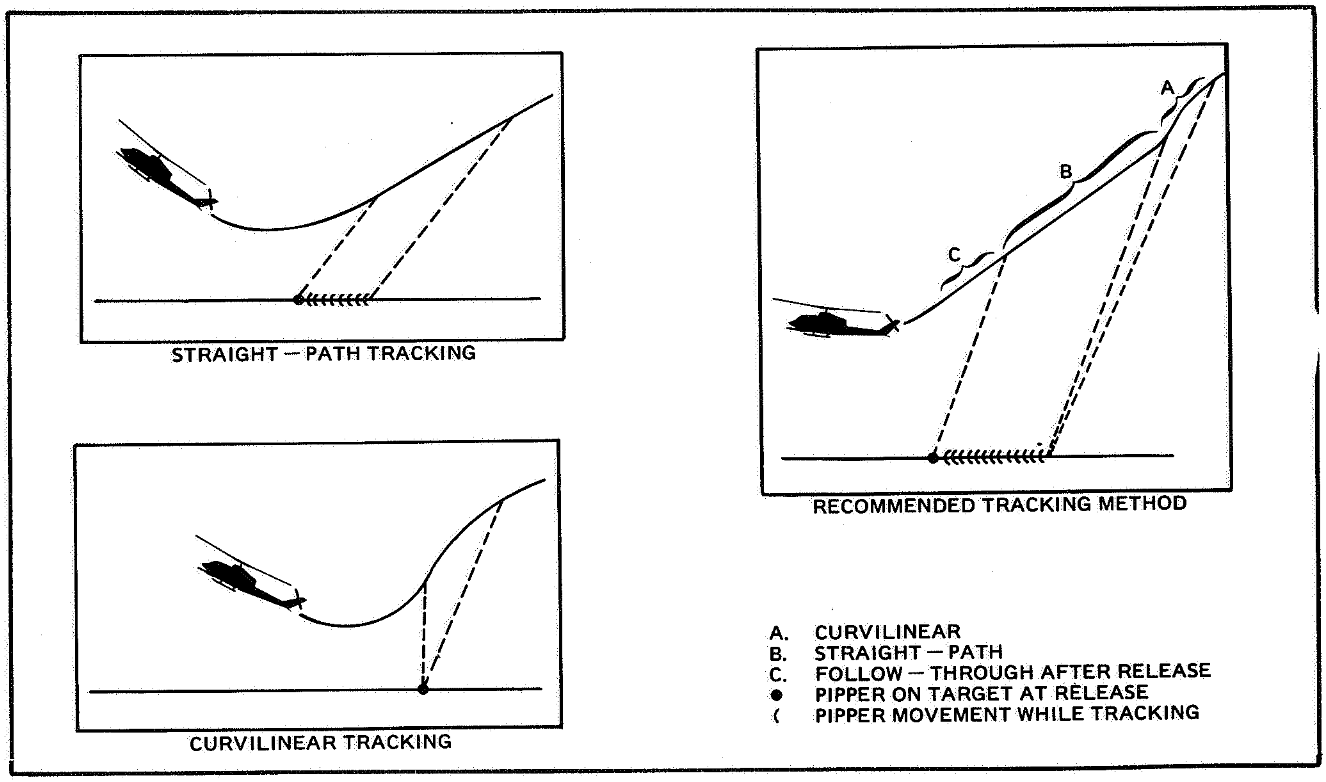

STRAIGHT — PATH TRACKING
CURVILINEAR TRACKING
A
B
C
RECOMMENDED TRACKING METHOD
A. CURVILINEAR
B. STRAIGHT — PATH
C. FOLLOW — THROUGH AFTER RELEASE
● PIPPER ON TARGET AT RELEASE
(PIPPER MOVEMENT WHILE TRACKING

Figure 2-6. Tracking

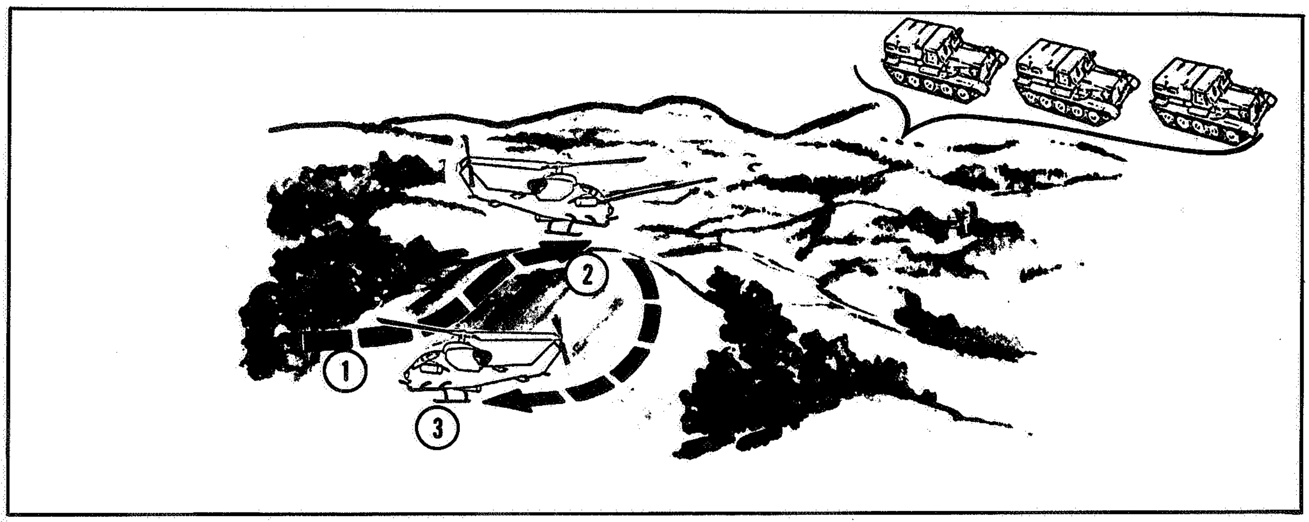


Figure 2-7. Running Fire

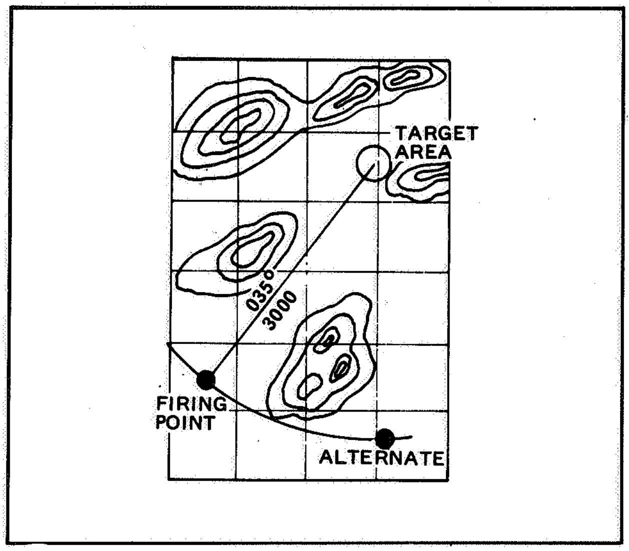


Figure 2-8. Firing Point

The length of time the gunsight can be held on the target is limited to a very short period of time. Firing should be stopped when the sight picture no longer can be maintained. This limitation is applicable for all delivery techniques that require a pitching motion to attain the desired firing attitude (Figure 2-13).

If additional firepower is required on the target after firing the initial volley, or adjustment is required to hit the target, the pilot should return to the firing point and repeat the running fire procedure. Alternate firing points should be selected to avoid repeated overflights of the same firing point (Figure 2-14).

2.2.3.2 Delivery Techniques, Indirect Fire, Rockets. Indirect fire is used primarily against area targets. The delivery technique used to conduct indirect fire differs primarily in the means used to determine the correct pitch attitude for the different ranges and the method of aiming the weapons. It is normally performed after unmasking from a firing position; however, indirect hover fire may be delivered from firing positions obscured from the enemy by terrain. Since indirect delivery techniques have not been developed for flex weapons, only stowed weapons will be discussed. To perform indirect fire, using either type of fire, the helicopter attitude indicator is the primary means of determining the required pitch attitude to attain the desired range. The proper firing data should be obtained from the terrain flight ordnance delivery charts. The method of selecting a firing point is the same as previously discussed except the target cannot be seen from the firing points. The direction to the target is then measured using a tactical map and converted to a magnetic heading.

The flight maneuver required during the firing phase is the same as previously discussed in direct fire; however, the sighting technique is different.

When using the attitude indicator to determine pitch attitude (Figure 2-15), the pilot may use either of two methods. One method is to adjust the horizon bar the desired number of degrees above the miniature aircraft (A); and, when over the firing point, raise the nose of the helicopter unit the miniature aircraft is level with the horizon bar (B).

A second method is to level the attitude indicator for the specific attack airspeed (normally 60 knots) (C). To fire, raise the nose of the helicopter until the miniature aircraft indicates the desired number of degrees above the horizon bar (D).

Note

To achieve the desired range for the specific pitch attitude identified on the sight card, the attitude of the helicopter prior to beginning the pitch-up maneuver should be approximately 5° noselow. (The attitude of the attack helicopter at 60-knots airspeed with the turret weapon installed and one-half load of 20-mm ammunition.) A higher or lower flight attitude will result

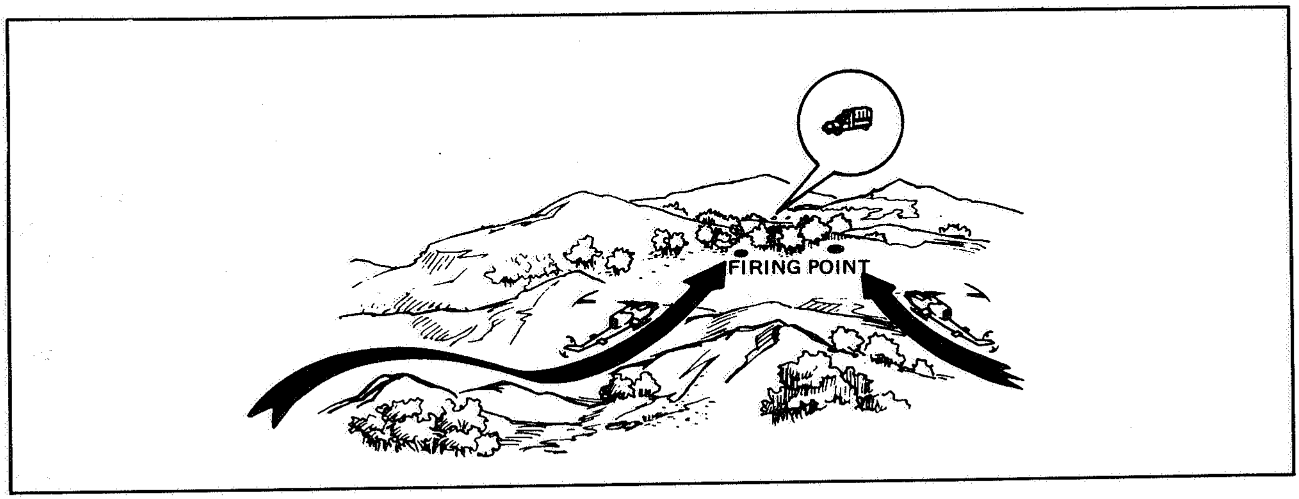


Figure 2-9. Overfly the Firing Point

in the rocket impacting beyond or short of the target.

2.2.3.3 Indirect Fire Delivery Techniques (Running Fire Using the Gunsight). A second sighting technique used for firing indirect running fire is to use the gunsight and a distant aiming point. This method is less accurate than other indirect delivery techniques, but effect on the target can be assured by using an observer to adjust fire on the target. To perform indirect fire, the aircrew must first select a firing point and determine the magnetic heading to the target. (The procedures used are the same as previously discussed.) After determining the range to the target, the required mil setting is placed on the mil scale of the gunsight.

Before firing the first round, a distant aiming point must be identified which will be used as a reference for establishing the pitch attitude and adjusting for deflection on subsequent firings. The helicopter should be positioned over the firing point and aligned with the target using the heading indicator. Viewing through the gunsight, the pilot selects a distant aiming point located between the firing point and the target (Figure 2-16). The distant aiming point must be located within the limits of the sight reticle and should be as close to the vertical crosshair as possible. It should be located at an elevation slightly higher than the firing point. A point is then marked on the horizontal crosshair of the sight reticle directly below the distant aiming point or a mental note is made of this position. This mark is referred to as the reference point in future discussions.

The pitch-up maneuver is similar to that used in direct fire except that the distant aiming point is used to sight on as opposed to the target. As the helicopter approaches the firing point, the heading indicator is used to maintain alignment with the target. When the distant aiming point comes into view through the gunsight, the pilot transitions from the heading indicator to the gunsight to maintain heading alignment with the target. Heading is maintained by positioning the distant aiming point along an imaginary vertical line projected up from the reference point. During the pitch-up maneuver, the correct sight picture is attained when the distant aiming point is superimposed on the reference point (Figure 2-17).

2.2.4 Hovering Fire. Hovering fire is fire delivered when the helicopter is below effective translational flight. Hovering fire can be be

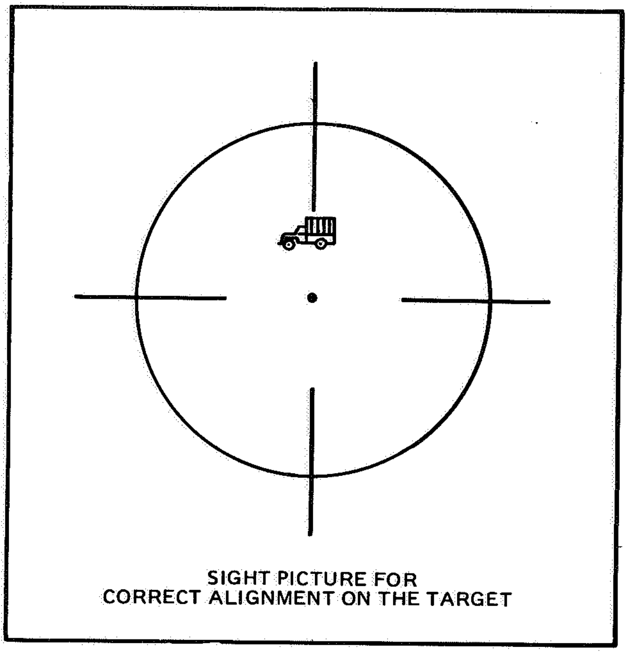


Figure 2-10. Correct Sight Picture for Alignment

delivered from any altitude. However, because of decreased accuracy and increased vulnerability over translation flight, hovering fire is recommended only in the terrain flying environment.

2.2.4.1 Direct Fire Delivery Techniques (Hover Fire). When performing direct hover fire, a firing point is selected which is approximately the same distance to the target as one of the ranges on the Terrain Flight Ordnance Delivery Charts (Appendix H). Place the mil setting corresponding to the desired range on the mil scale. When engaging the target, cyclic is applied to adjust the nose of the helicopter until the pipper is on the target; simultaneously, collective pitch is applied as necessary to keep the tail rotor from hitting terrain obstacles (Figure 2-18).

Once the proper sight picture is achieved, the weapon is fired (Figure 2-19).

When engaging targets at short ranges, forward movement may occur because of the nose-low attitude required to hit the target. Conversely, when engaging targets at the maximum range of the weapons system, rearward flight may result. Caution may be taken to ensure obstacle clearance behind the helicopter before firing (Figure 2-20).

2.2.4.2 Indirect Fire Delivery Techniques (Stable Fire). The stable indirect hover delivery technique does not require an attitude change of the helicopter to fire the weapon. A limitation of this delivery technique is that only one range can be fired. During premission planning, the QE on the launchers should be set for the most desired range. To accurately engage a target, a firing point must be selected at a distance from the target equal to the range for the QE set on the launcher (Figure 2-21). The procedures for determining the firing heading are the same as previously discussed.

When the target is to be engaged, the pilot establishes a stabilized hover over the firing point and aligns the helicopter with the target by referring to the heading indicator. The target is engaged from the hover attitude. This technique has the advantage that large volumes of fire can be placed on the target while maintaining a stabilized firing attitude (Figure 2-22).

Indirect hover fire is conducted from a selected point on the ground. The aircrew must know the heading to the target and the approximate range. The procedures for selecting a firing point and determining the firing heading are the same as previously discussed. Both sighting techniques (attitude indicator and gunsight) for indirect running fire can be used for indirect hover fire.

When the prefiring procedures have been completed, the pilot aligns the helicopter with the target at a stabilized hover using heading indicator or the distant aiming point.

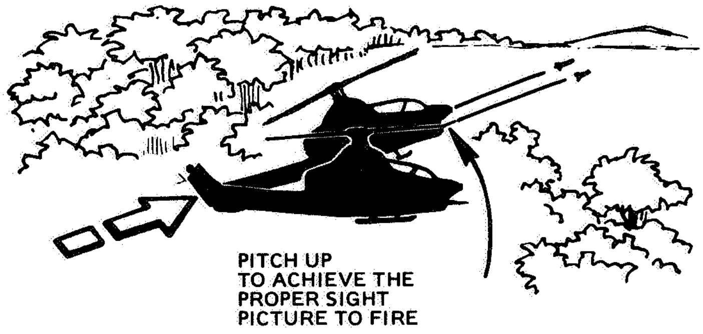


Figure 2-11. Pitch-Up For Proper Sight Picture

The pitch-up maneuver is initiated by applying aft cyclic. Simultaneously, collective pitch is added to keep the tail rotor clear of obstacles. The desired pitch attitude is indicated by the position of the miniature aricraft on the horizon bar or the horizontal crosshair on the gunsight is level with the distant aiming point. The effect of tuck when firing and the rearward movement of the helicopter must be anticipated by the pilot (Figure 2-23).

2.3 WEAPON DELIVERY BALLISTICS

Ballistics is the science which deals with the motion of projectiles and the conditions which affect that motion. The factors dealt with herein are not intended to be all encompassing, but are felt to be those needed by the aircrew to place effective fire on the target with the least expenditure of ammunition. The three types of ballistics are: interior (factors which affect the accuracy of the weapon before it leaves the launcher tube), exterior (factors which affect the accuracy of the projectile as it moves along its trajectory), and terminal (factors which affect the weapon at impact).

2.3.1 Interior Ballistics. Interior ballistics deals with the factors affecting the motion of the projectile within the tube. These factors affect the accuracy of all aerial-fired weapons and cannot be compensated for by the aircrew.

2.3.1.1 Tube Wear. Residues generated by burning propellant and movement of the projectile through the tube may either wear away the inner surface of the tube or cause deposits to build up within it. Either condition results in a loss of muzzle velocity and may induce excessive yaw.

2.3.1.2 Propellant Charge. Propellant charges for aerial weapons are fixed; however, there are minute differences in muzzle velocity and trajectory due to production variation. In addition, propellant burning is affected by temperature and moisture encountered in the storage environment.

2.3.1.3 Projectile Weight. Projectiles of the same caliber may vary within tolerance in weight. This is especially true in linked ball and tracer ammunition. The heavier projectile with all other factors remaining unchanged will have a lower velocity.

2.3.1.4 Tipoff. Because the inside diameter of the rocket launcher tube is larger than the rocket, the rocket can exit the tube with an error in any direction. If, for example, the first

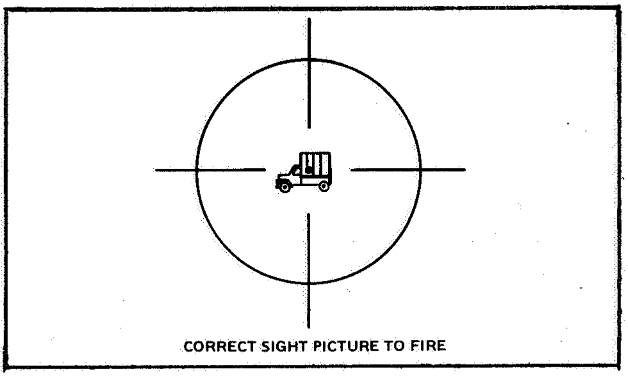


Figure 2-12. Correct Sight Picture to Fire

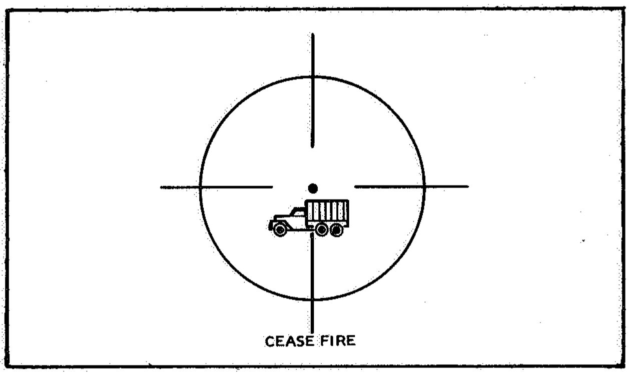


Figure 2-13. Correct Picture For Cease Fire

rocket exits the tube pointing above the axis of the pod and the second exits the tube pointing right and down, the two rockets may move on divergent courses. When firing from a hover, relative wind cannot correct for this error; therefore, the rockets scatter more than those launched in forward flight.

2.3.1.5 Launcher Tube Alignment. The launcher is composed of individual tubes which are replaced when excessive wear occurs. Alignment of the tubes is maintained by the end plates; however, accurate alignment of the tubes cannot be achieved. Because of variances in alignment, the boresight is only accurate for the tube that is used when boresighting the weapon to the gunsight. To minimize the error that is imparted to the rocket due to tube misalignment, armament personnel should check several tubes and select the one with the least alignment error to boresight the weapon.

2.3.2 Exterior Ballistics. Exterior ballistics deals with the factors that affect the motion of the projectile as it moves along the trajectory. The trajectory is the path described by the center of gravity of the projectile as it passes from the muzzle of the weapon to the point of impact. Aerial-fired weapons have all the exterior ballistic factors associated with short-range, ground-fired weapons plus other factors which are unique to helicopters as discussed below.

2.3.2.1 General Ballistic Factors. The exterior ballistic factors that affect all weapons systems are as follows:

2.3.2.1.1 Air Resistance (Drag). Drag is caused by the friction between the air and the projectile. It opposes and reduces the velocity of the projectile, causing it to fall short of its maximum range. Drag is proportional to both the cross-sectional area of the projectile and its velocity.

2.3.2.1.2 Yaw. Yaw is the angle between the centerline of the projectile and the trajectory. Yaw causes the trajectory to change and increases drag. The direction of the angle of yaw is constantly changing in a spinner projectile. Yaw is at a maximum near the muzzle and gradually subsides as the projectile stabilizes.

2.3.2.1.3 Projectile Drift (Horizontal Plane Gyroscopic Effects). U.S. projectiles, as viewed from the rear, spin in a clockwise direction. A spinning projectile acts as a gyroscope and exhibits the characteristic know as gryoscopic precession. This force causes the projectile to precess, or move to the right. To compensate for this effect, it is necessary to aim to the left of the target. As the range increases, the effects of projectile drift increase, and more correction is required to cause the projectile to hit the target. The effect of projectile

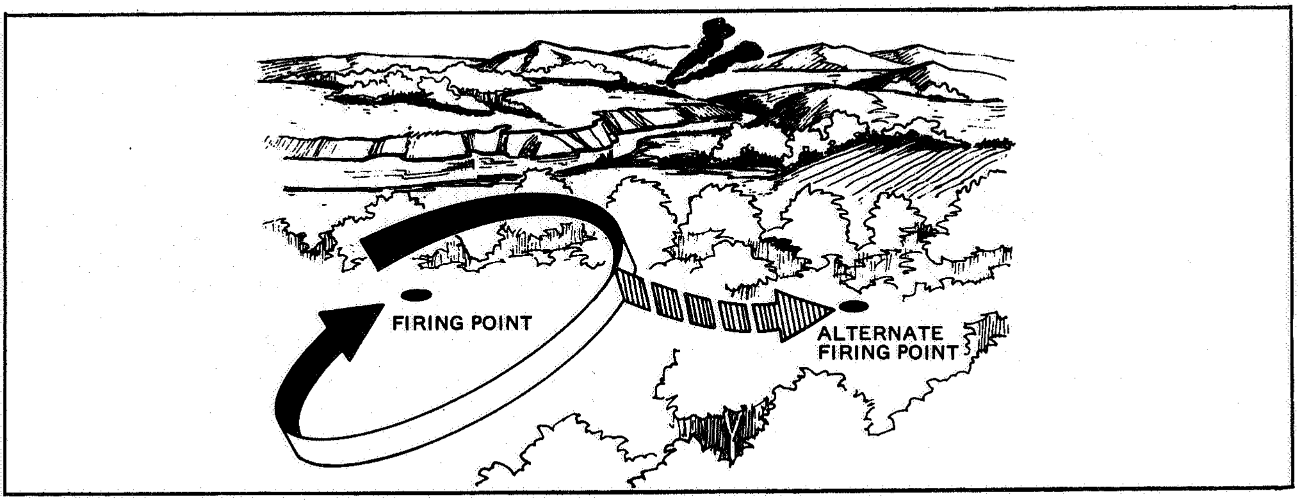


Figure 2-14. Repeat Fire With Alternate Firing Point

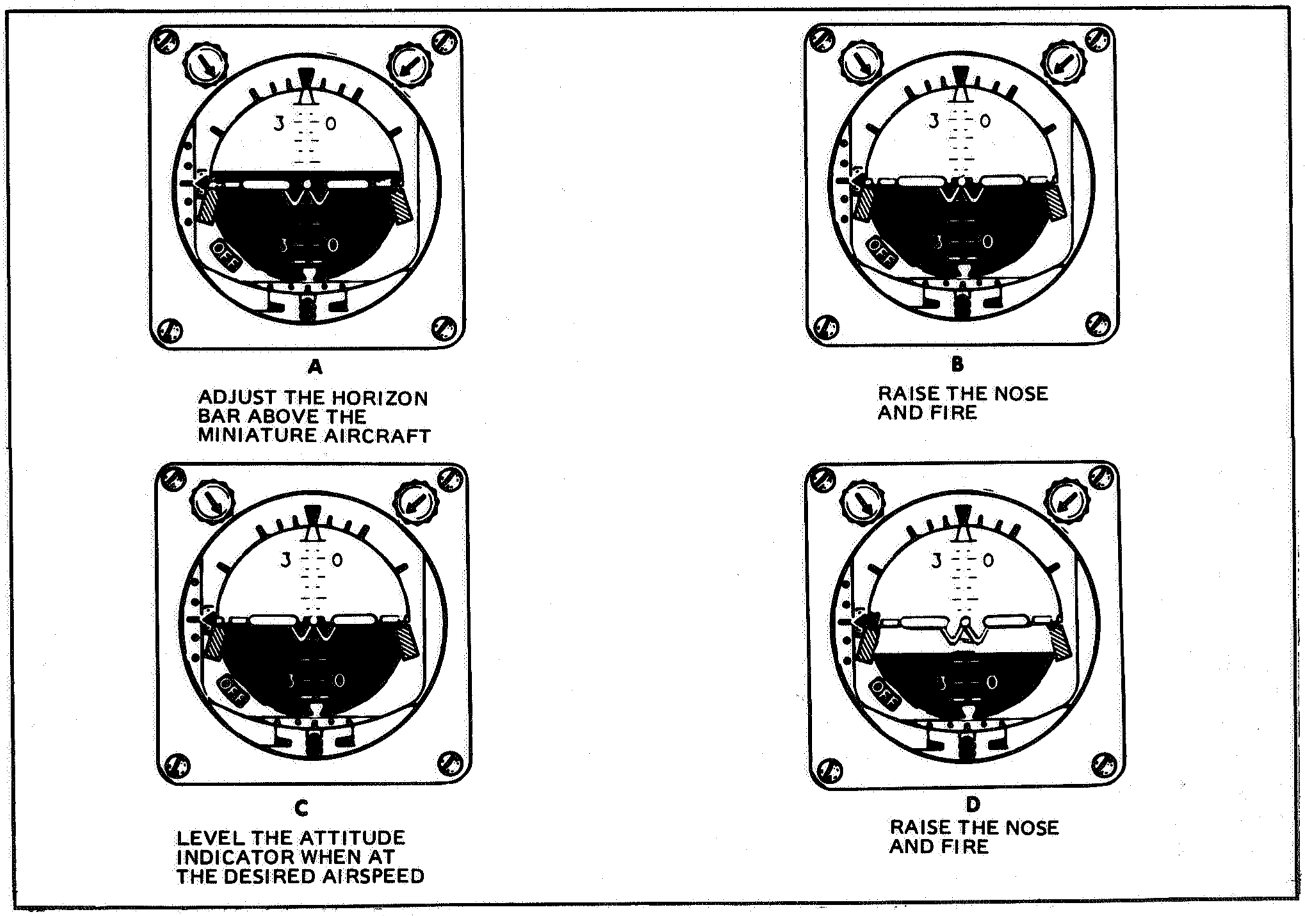

A
ADJUST THE HORIZON BAR ABOVE THE MINIATURE AIRCRAFT
B
RAISE THE NOSE AND FIRE
C
LEVEL THE ATTITUDE INDICATOR WHEN AT THE DESIRED AIRSPEED
D
RAISE THE NOSE AND FIRE

Figure 2-15. Using the Attitude Indicator to Determine Pitch Attitude

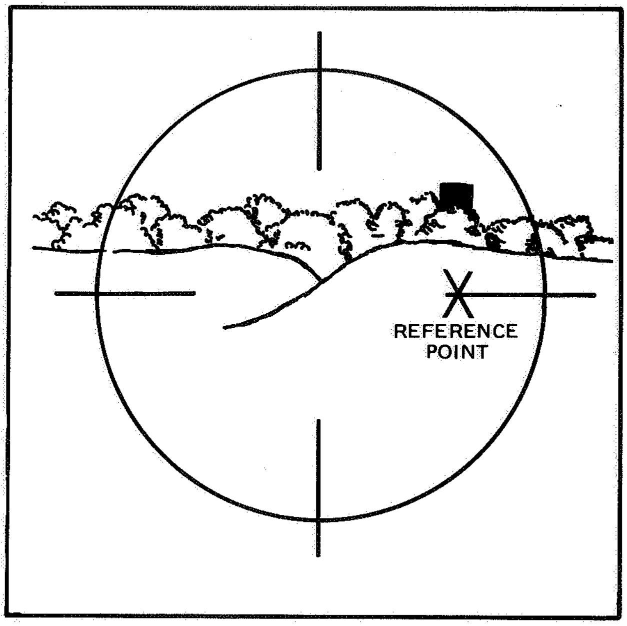


Figure 2-16. Distant Aiming Point Using Gunsight

drift is compensated for when establishing combat sights or harmonizing the turret weapons.

2.3.2.1.4 Gravity. The effects of gravity will cause an object to drop below its normal flightpath. The amount of drop depends on the time of flight (distance) to the target and the muzzle velocity of the projectile. The effect of gravity drop is corrected for when the turret weapons are harmonized. The mil setting on the sight card for the 2.75-inch FFAR compensates for gravity drop (Figure 2-24).

2.3.2.1.5 Wind Drift. Wind drift is the lateral movement of the projectile that is caused by a force acting on the projectile within flight. The amount of drift depends on the projectile's time of flight and the windspeed acting on the cross-sectional area of the projectile. Time of flight depends upon the range to the target and the average velocity of the projectile over this range. Firing into a crosswind requires that the weapons be aimed upwind to allow the wind to drift the projectile back to the target. For weapons systems which do not compensate for the effect of projectile drift, it may correct for wind drift, or amplify the problem, depending upon the direction the wind is acting upon the projectile. Firing into the wind or downwind will require no compensation laterally, but some adjustment is required in range.

2.3.2.2 Aerial Ballistics. The exterior ballistic factors peculiar to aerial-fired weapons are dependent on whether the projectiles are spin-stabilized, or fin-stabilized, and whether they are fired from the fixed mode or the flexible mode. However, there are factors that are common only to helicopters, such as those discussed below.

2.3.2.2.1 Rotorwash Error. Rotorwash is a force acting on the projectile that is caused by the rotor. This force has an appreciable effect only if the helicopter's translational speed is less than 30 knots. Rotorwash affects the accuracy of all weapons; however, the 2.75-inch FFAR is affected the most. When the helicopter is hovering in ground effect the combination of downwash and reflected downwash causes the rocket to wobble, thus introducing both lateral and linear error. Hovering out-of-ground effect decreases lateral error but may inrease linear dispersion. In hovering flight, whether in or out of ground effect rockets fired from the right side of the helicopter are affected more by rotorwash than rockets fired from the left side, and tend to land farther.

2.3.2.2.2 Angular Rate Error. Angular rate error is an error imparted to the projectile by the movement of the helicopter. The amount of error that is induced is determined by the distance to the target, the rate of motion, and the airspeed of the helicopter prior to firing the weapon. Angular rate error also occurs when firing from a hover using the pitchup delivery technique, but to a lesser degree. Any time a pitchdown motion is required to achieve the desired sight picture, the effect of angular rate error causes the projectile to land short of the target (Figure 2-25).

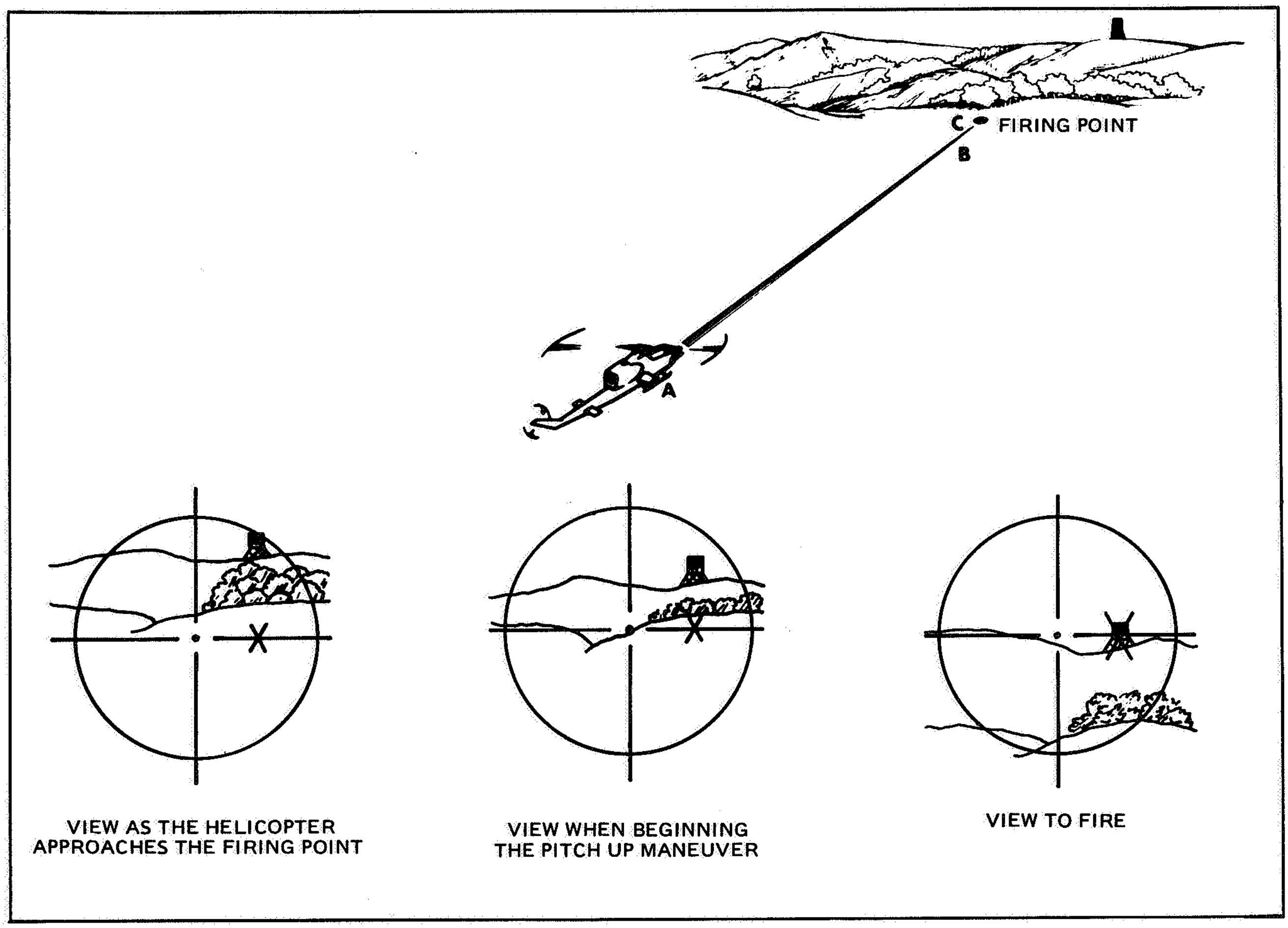

C
FIRING POINT
B
A
VIEW AS THE HELICOPTER APPROACHES THE FIRING POINT
VIEW WHEN BEGINNING THE PITCH UP MANEUVER
VIEW TO FIRE

Figure 2-17. Correct Sighting Picture With Gunsight

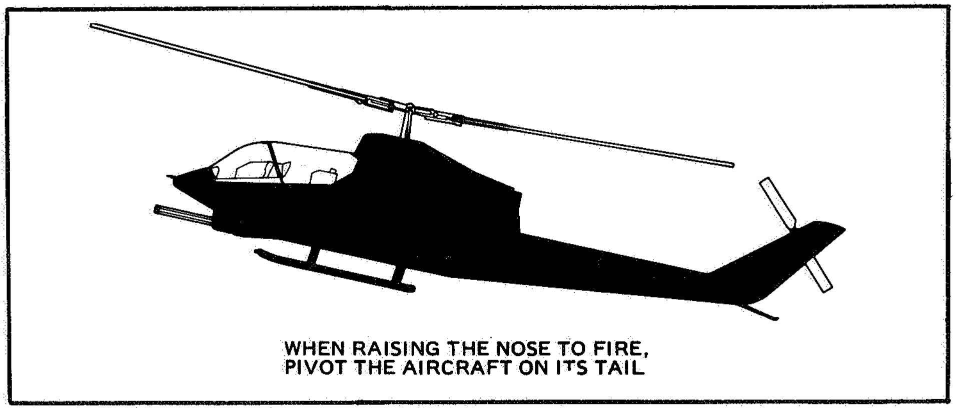

WHEN RAISING THE NOSE TO FIRE,
PIVOT THE AIRCRAFT ON ITS TAIL

Figure 2-18. Cyclic and Collective Adjustment for Firing From a Hover

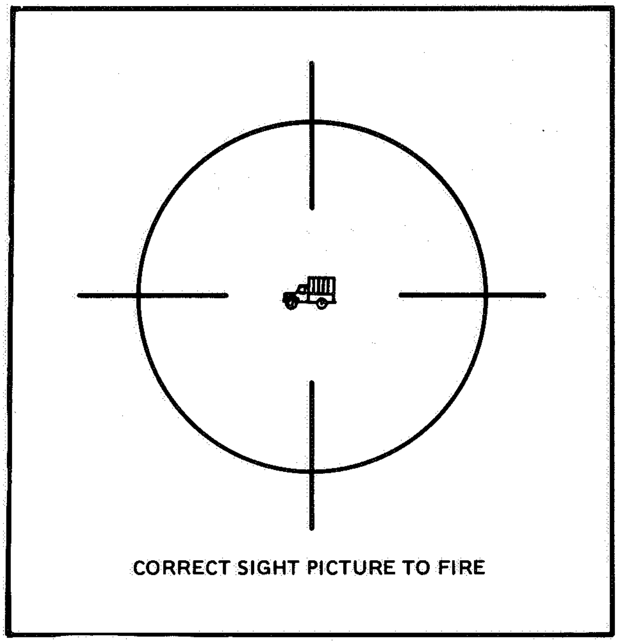


Figure 2-19. Correct Sight Picture for Hover Fire

2.3.2.3 Aerial Ballistics of Spin-Stabilized Projectiles. There are certain aerial exterior ballistic factors peculiar to spin-stabilized projectiles fired from weapons with rifled barrels (e.g., 20 mm). When fired in the fixed mode (straight ahead of the helicopter), generally they have the same ballistic factors common to ground-fired weapons, except the relative wind changes and the velocity of the platform (helicopter) is added to the velocity of the projectile. The ballistic factors affecting spin-stabilized projectiles fired in the flexible mode are as follows.

2.3.2.3.1 Trajectory Shift. When the boreline axis of the weapon differs from the flightpath of the helicopter, the forward velocity of the helicopter causes a change in the direction and velocity of the projectile. For deflection shots within 90° of either side of the helicopter heading, trajectory shift will cause the round to be left or right of the target when the gunsight is aimed at the target (Figure 3-29). Trajectory shift is corrected by leading the target (fire placed on the near side of the target as the helicopter approaches it). The amount of lead is dependent upon the airspeed of the helicopter, deflection angle, velocity of the projectile, and target range. Some typical lead angle values are shown below (Figure 2-27). Compensation for trajectory shift is not required when firing from a stationary hover.

2.3.2.3.2 Post-Starboard Effect. When firing flex weapons, the effect of trajectory shift and projectile drift results in the port-starboard effect. When firing at targets on the portside (left), the effects of drift and shift compound each other because both effects are to the right. To hit the target with the weapons system, the gunner must apply correction for both ballistic effects by firing to the left (near side) of the target. When firing to the starboard (right) side, the effect of projectile drift (the round moves right) tends to cancel the effect of trajectory shift (the round moves left) and less compensation is required (Figure 2-28). The range to the target and airspeed of the helicopter will determine which effect is greater. For example, at close ranges (less than 1000 meters), trajectory shift is greater and the gunner must fire to the right of the target. At longer ranges (beyond 1000 meters), the effect of projectile drift is greater and it tends to cancel the effects of trajectory shift.

Note

> If the compensation system is activated, no correction is required for the turret guns.

2.3.2.3.3 Projectile Jump (Vertical Plane Gyroscopic Effect). If a projectile is fired in any direction other than along the helicopter line of flight, an initial yaw due to the crosswind will be induced (not to be confused with Magnus effect). A projectile elevation jump is produced which is proportional to initial yaw. For a projectile with a clockwise spin, firing to the right produces a downward jump and firing to the left produces an upward jump. Since compensation devices do not correct for this effect, the gunner must aim slightly below the

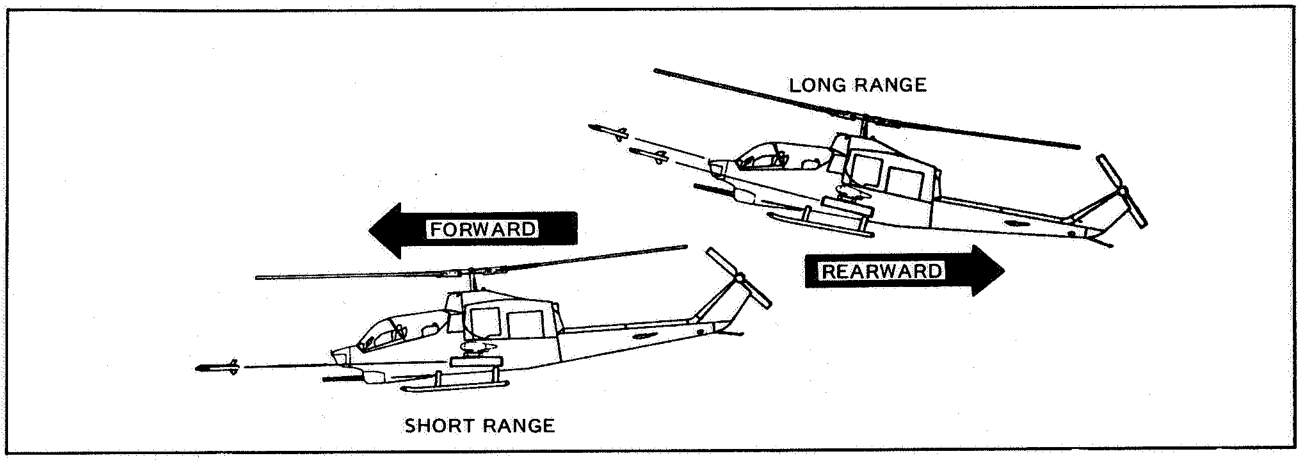


Figure 2-20. Forward Movement at Short Range — Rearward Movement at Long Range

target when firing to the left and slightly above when firing to the right unless firing from a hover. The amount of correction increases as velocity and angular deflection increase (Figure 2-29).

2.3.2.4 Aerial Ballistics of Fin-Stabilized Projectiles. The exterior ballistic factors affecting fin-stabilized projectiles are of major importance. These factors are as follows.

2.3.2.4.1 Propellant Force. A bullet has its maximum velocity at the muzzle; however, a rocket continues to accelerate until motor burnout occurs (approximately 1.7 seconds after launch for present motors). As the rocket reaches its maximum velocity, the kinetic energy of the rocket tends to overcome other forces and causes the rocket to travel in a straight line of flight. To provide equalization of thrust from exhaust nozzles, fin-stabilized rockets are designed to rotate. However, the rate of rotation is so small (less than 25 revolutions/second) that gyroscopic precession and yaw are insignificant.

2.3.2.4.2 Center of Gravity. Unlike a bullet, the center of gravity of a rocket is forward of the center of pressure. As the rocket propellant

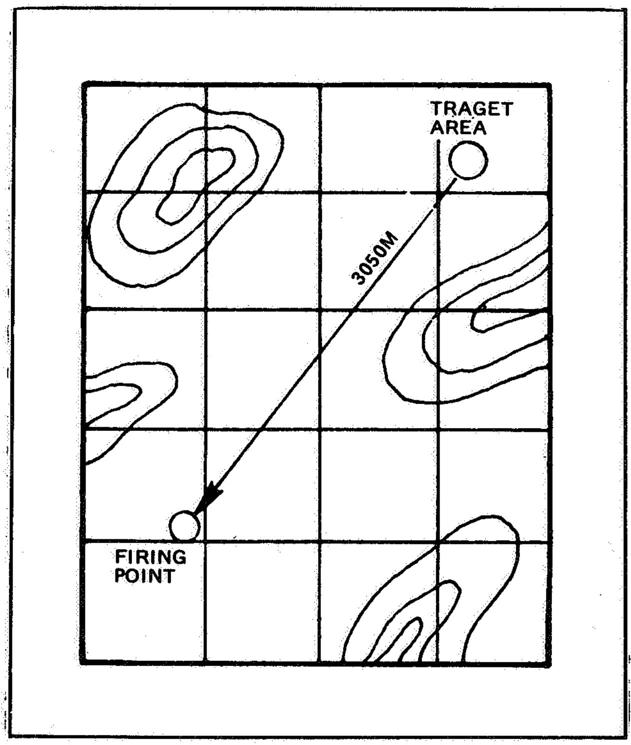


Figure 2-21. Stable Indirect Hover Firing Point

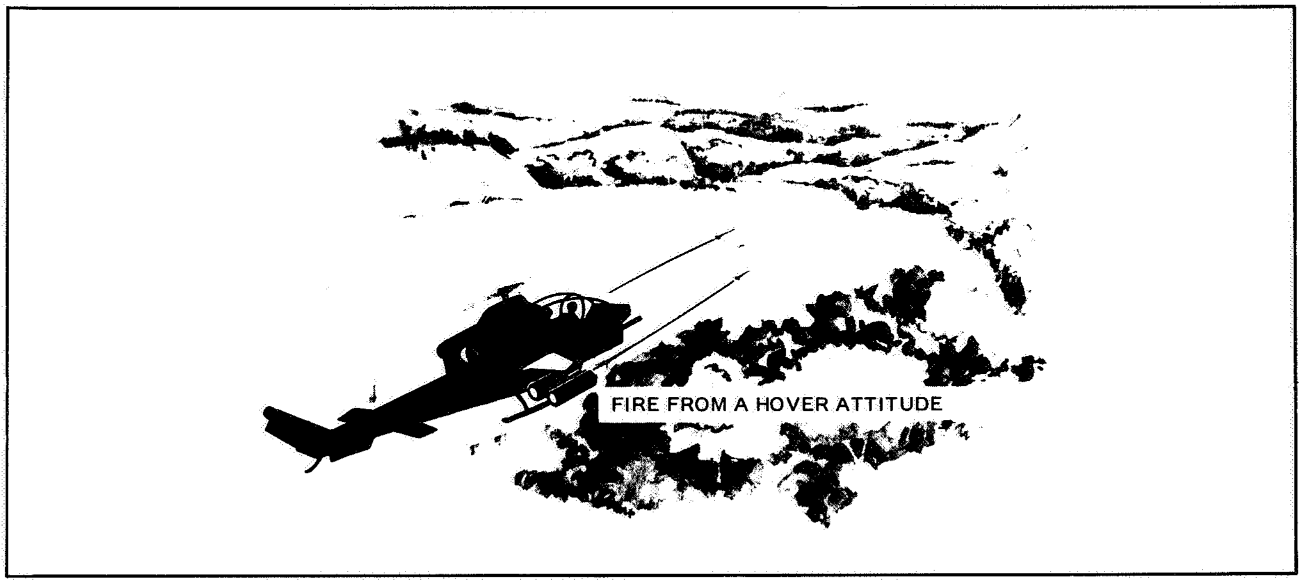

FIRE FROM A HOVER ATTITUDE

Figure 2-22. Fire From a Hover Attitude

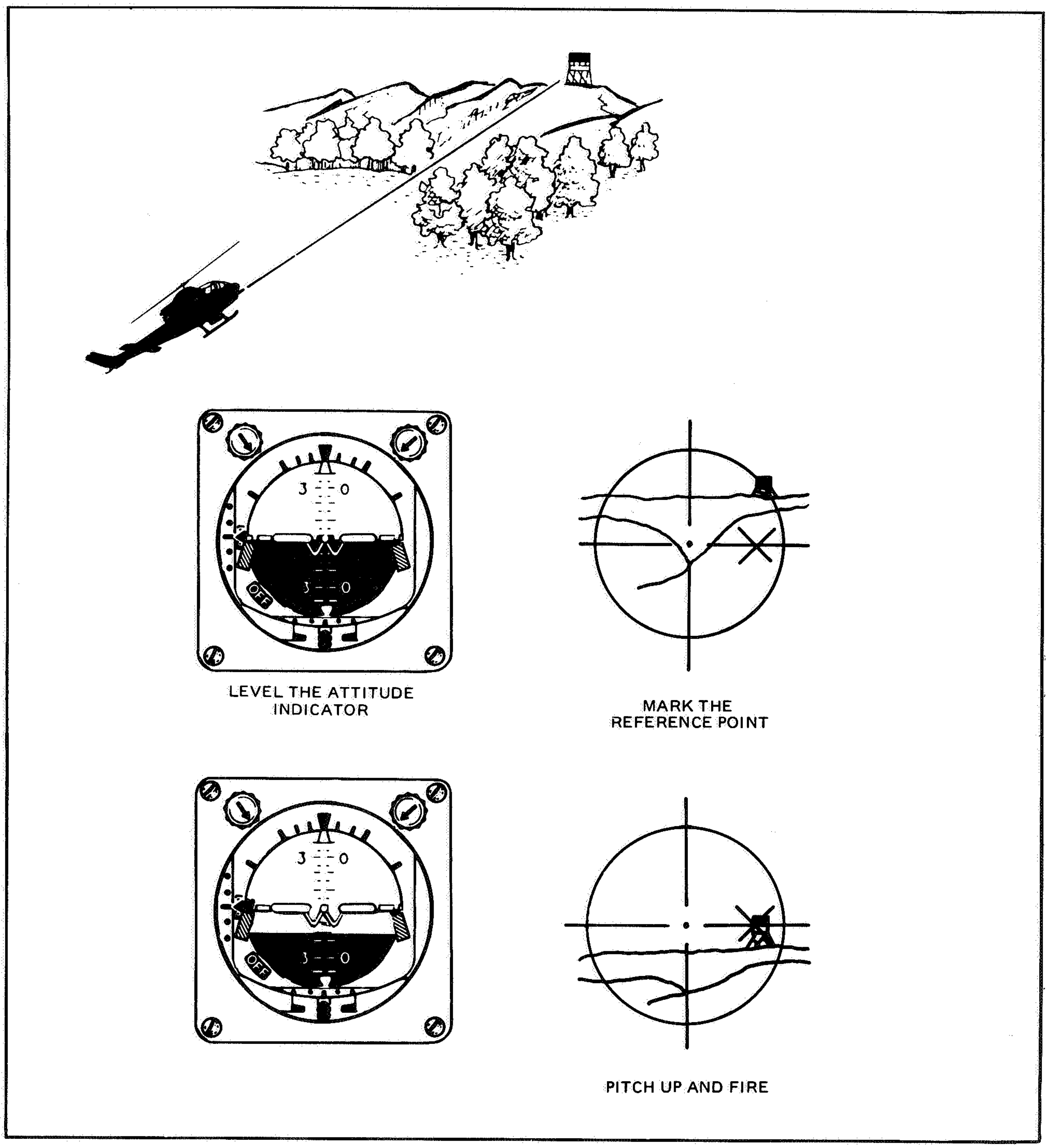
is consumed, the center of gravity moves farther forward. The primary purpose of the fins is to ensure that the center of pressure follows the center of gravity. If the fins do not open, theoretically, the rocket will nose over and impact short of the target. In practice, the weapon may fly in any direction and manner.

2.3.2.4.3 Crosswind Effects. The effect of a crosswind on a rocket's trajectory depends on whether or not the ground track of the rocket was being held constant at release. If the helicopter is allowed to displace with the wind; i.e., drift, at release, the only effect that need be considered is the drift of the rocket due to the crosswind (Figure 2-30). In this case, the rocket will drift with the crosswind an amount dependent on the wind velocity and rocket time of flight. To compensate for this, the pilot copilot's aim must be upwind of the target. If, however, the aircraft is following a straight ground track at release, with a crosswind, the rocket will be affected by both drift and a change in direction of rocket axis. Since the extended fins are the largest surface area of the rocket, the rocket will pivot about its center of gravity into the relative wind (Figure 2-31).

This redirects the rocket into the wind. At the same time, the drift as mentioned above is acting on the system. Since these two affects oppose each other, the rocket may impact either upwind or downwind of the target, depending on which effect predominates (based on time of flight, rocket velocity, etc.).

In the situation defined in Figure 2-30, the gunner may experience an optical illusion which makes the helicopter appear to displace laterally farther than the rocket. This is due to the greater down range travel of the rocket. The gunner sees this motion, relative to himself, causing the illusion of the rocket curving into the crosswind.

2.3.2.4.4 Relative Wind Effect. If the helicopter is not in a trimmed condition either horizontally or vertically at rocket launch, a relative wind will be created that will not be directed along the launch axis of the rocket. This wind acts on the larger surface area of the fins and causes the rocket nose to displace into it.



LEVEL THE ATTITUDE INDICATOR

MARK THE REFERENCE POINT

PITCH UP AND FIRE

Figure 2-23. Pitch-Up Maneuver When Firing

CORRECTIONS FOR GRAVITY DROP

Round	Muzzle Velocity (Feet Per Second)	Range (Meters)	Gravity Drop Corrections (mils)
20MM	3380	1000	5.88

Figure 2-24. Correction for Gravity Drop

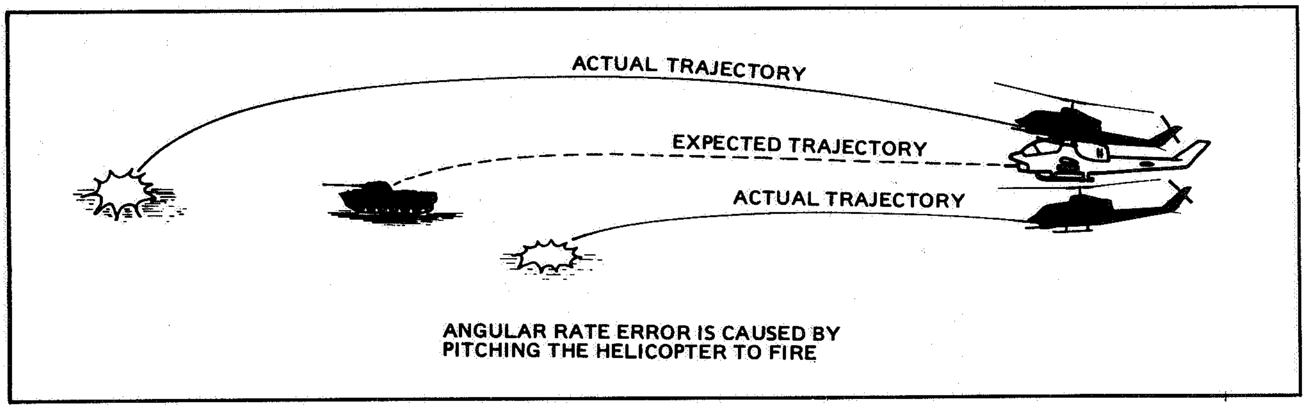

ACTUAL TRAJECTORY
EXPECTED TRAJECTORY
ACTUAL TRAJECTORY
ANGULAR RATE ERROR IS CAUSED BY PITCHING THE HELICOPTER TO FIRE

Figure 2-25. Angular Rate Error

A horizontal out-of-trim condition is usually the result of the pilot trying to maintain a straight ground track to the target during a crosswind. He does this by cross-controlling (or slipping) the aircraft. The situation is then the same as with the crosswind effect mentioned above. Aimpoint will be upwind of the target at high release velocity and extremely long ranges and downwind of the target otherwise.

A vertical out-of-trim condition is the result of improper power setting which creates a vertical relative wind (up or down) on the rocket at launch. For example, a rocket fired while the helicopter is in autorotation sees a relative upward wind, will turn down into the wind, and impact short of the target. If the rocket is fired in an accelerating climb, the rocket will turn up into the wind and impact long. To maintain a vertical trim condition, adjust to a power setting that will maintain a desired airspeed and altitude or rate of descent.

Any combination of vertical and horizontal out-of-trim can also occur. For example, if the helicopter is firing while hovering in a crosswind, then because of the downward relative wind from the rotorwash and the crosswind, the rocket will turn up and into the crosswind.

Trajectory errors due to relative wind cannot be accurately predicted and corrected during the initial firing. Corrections are therefore applied to hit the target after observing the impacts of the initial firing.

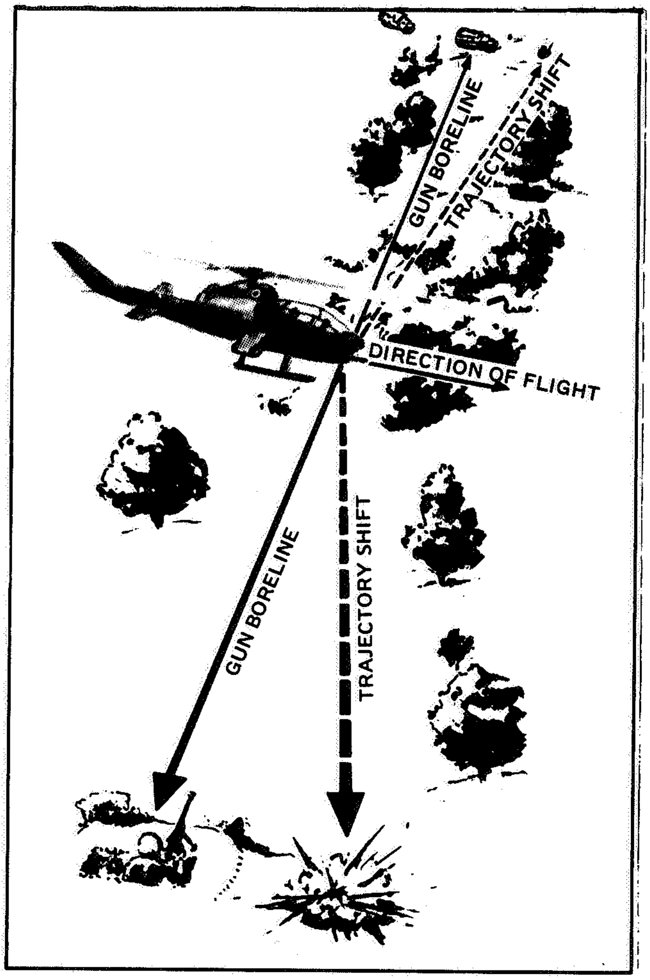


Figure 2-26. Trajectory Shift

2.3.2.4.5 Miscellaneous. Trajectory errors due to unequal burning of propellant, and turbulence due to previous rockets in a salvo, or due to firing rockets with varying size warheads in the same load cannot be predicted.

2.3.3 Terminal Ballistics. Terminal ballistics concern those factors which affect the projectile at the target. Projectile functioning (i.e., blast, heat, fragmentation) is influenced by fuze functioning and warhead, angle of impact, and surface condition.

2.3.3.1 Fuzing. Fuzing can be of the impact, proximity, or timed type. Impact fuzes can be instantaneous (producing surface detonation) or delay (detonating after penetration). Proximity fuzes detonate at some preset distance from the target, thus producing an airburst. Timed fuzes produce detonation at some preset time after arming.

2.3.3.2 Angle of Impact. The angle at which the projectile strikes the target area affects the dispersion pattern. Weapons fired while in a dive produce fragmentation patterns which are compact. When firing from NOE altitudes at the midrange of the weapon (low impact angle), an elongated pattern is formed (Figure 2-32). As the range increases, impact angle of the projectile increases and the size of the fragmentation pattern decreases.

2.3.3.3 Surface Conditions. The condition of the target surface area affects the lethality of the weapon. If point-detonating fuzed weapons are employed on terrain covered with heavy foliage, the weapon will detonate high in the tree canopy with little or no lethal effect at ground level. If delay-type fuzed projectiles are employed on soft terrain, the warheads will penetrate the surface before detonation, thus decreasing lethal bursting radius.

2.3.4 Dispersion. If a number of projectiles are fired from the same weapon with the same settings in elevation and deflection, the points of impact of the projectiles will be scattered both in deflection and range. Dispersion is caused by errors inherent in firing the projectile. These errors are caused in part by:

1. Conditions in the bore — muzzle velocity is affected by variations in weight, moisture content, and temperature of the propellant charge; variations in the arrangement and content of the powder grains; differences in projectile weight; and variations in the temperature of the bore and tube.

LEAD ANGLE VALUES

(60 Degree Deflection at 1000 Meters)

Round	Muzzle Velocity (Feet Per Second)	Helicopter Velocity (Knots)	Lead Angle (Mils)
20MM	3380	100/200	47/94

Figure 2-27. Lead Angle Values

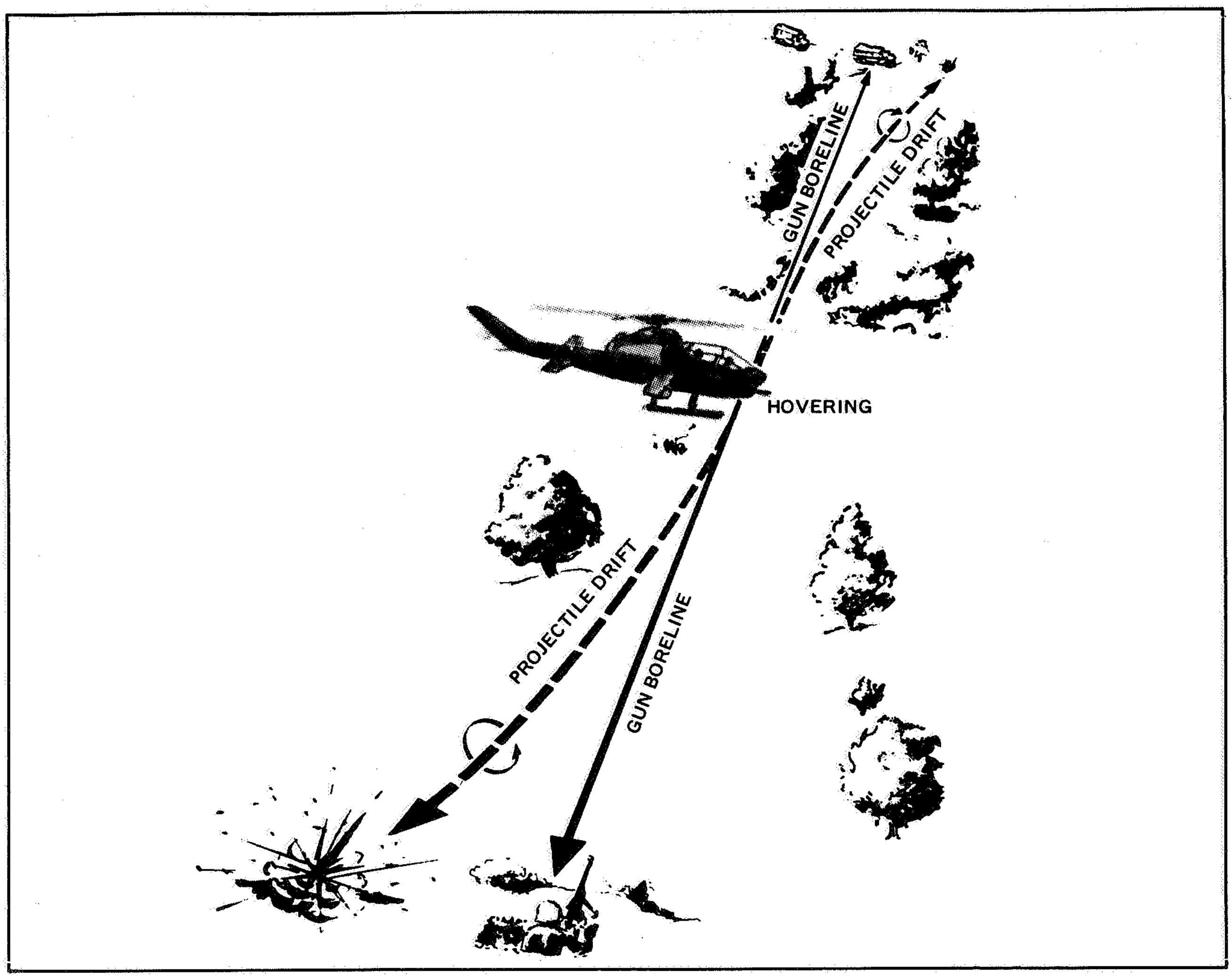


Figure 2-28. Projectile Drift Without Compensation System

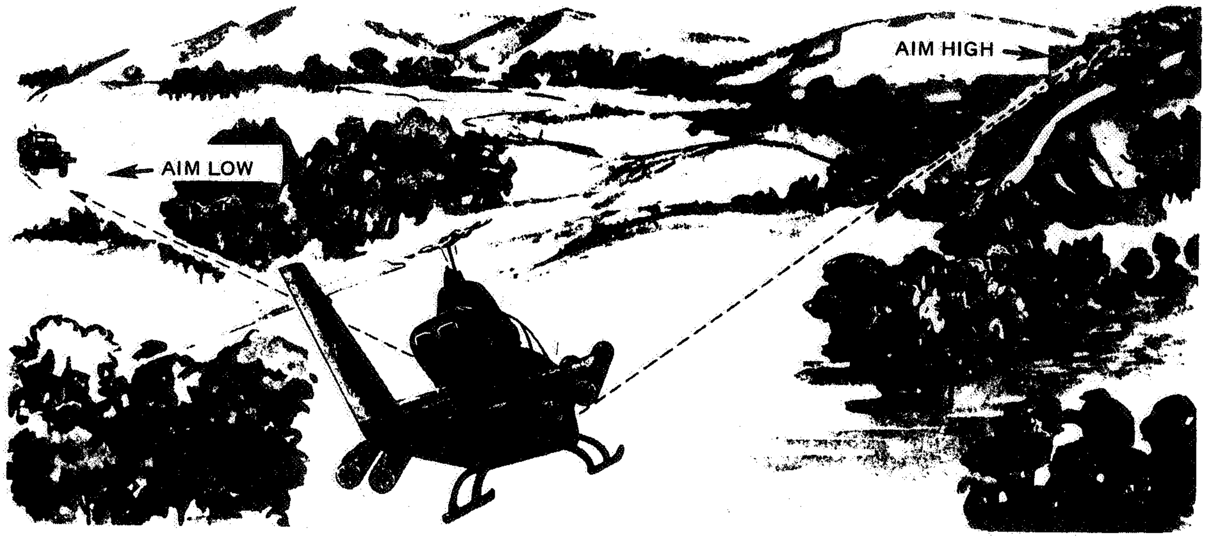


Figure 2-29. Projectile Jump

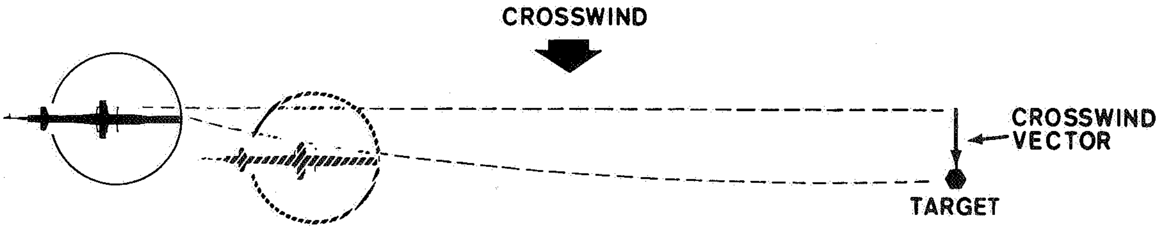


Figure 2-30. Crosswind Effect, Helicopter Sideslipping

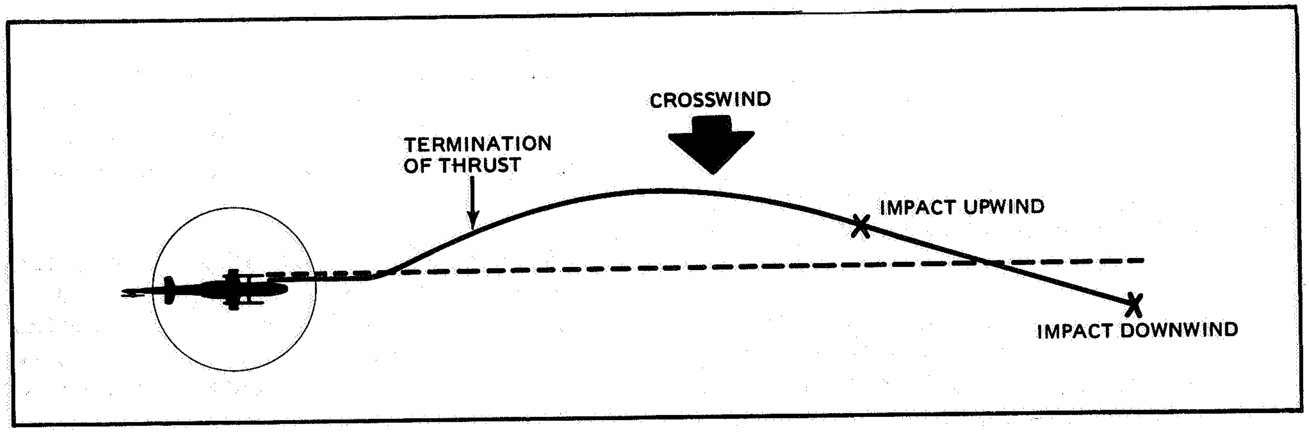


Figure 2-31. Crosswind Effect on Constant Ground Track

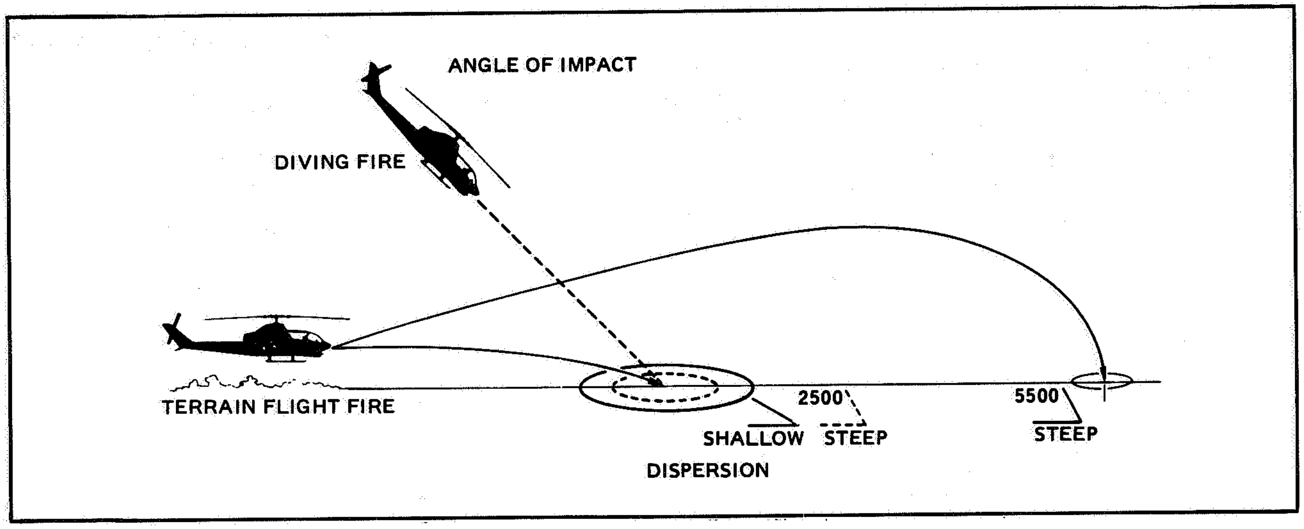


Figure 2-32. Angle of Impact

2. Conditions in the mount — deflection and elevation are affected by looseness in the mount and unequal reaction to firing stresses.

3. Vibrations in the mount — vibrations in the helicopter are transmitted through the mount and affect both deflection and elevation.

4. Conditions during flight — from round to round, air resistance (drag) is affected by differences in velocity and form of projectile.

2.4 DIVE DELIVERY DATA TABLES/ ERROR ANALYSIS

2.4.1 Release Condition Effects. The factors which affect weapons delivery accuracy are dive angle, release altitude, coordinated flight, wind, and target motion. Sight angles are computed for each weapon at specific release conditions, and only at these conditions will the weapon trajectory and sight line intersect at the target.

2.4.1.1 Release Altitude. The effect of an error in release altitude is shown in Figure 2-33. Altitude errors have the same effect in dive and level delivery: if release altitude is too high, the result is an early sight picture, and a short hit; for lower than planned release altitudes, sight picture is late, and the hit is long.

2.4.1.2 Release Airspeed. The effects of release airspeed errors in dive and level delivery are shown in Figure 2-34. If the helicopter is at the proper dive angle and altitude, the hit will be long for airspeeds faster than planned. For airspeeds slower than planned, hits will be short.

2.4.1.3 Angle of Attack and Gross Weight. The effects of errors in release angle of attack or gross weight can be related to errors due to airspeed. At constant weight, higher angle of attack dictates lower airspeeds, for heavier weights. If the angle of attack is too low (more nose-down), or the weight is lower than planned, the result is a late sight picture and a long hit. Conversely, if the angle of attack or weight are higher than planned, the result will be an early sight picture and a short hit.

2.4.1.4 G-Loading. Pitching the helicopter at the time of weapon release will cause several errors which affect delivery accuracy. Pulling positive g's is equivalent to lower airspeeds or higher angles of attack, resulting in an early sight picture and a short hit. Negative g's are similar to higher airspeeds and lower angles of attack which yield late sight pictures and long hits. Pitch-rate motion of the helicopter will also cause errors in trajectory as the result of aerodynamic, as well as tip-off effects on rockets and guns. All sight angle tables were compiled for the zero pitch-rate condition only.

2.4.1.5 Dive Angle. Figure 2-35 shows the effects of an error in dive angle. Given the correct release airspeed and altitude, a dive angle error will produce the following results: an early sight picture and a short hit for dive angles shallower than planned; a late sight picture and a long hit for dive angles steeper than planned. Precise control of dive angles is important, as attempts to correct an error in dive angle can readily result in large airspeed or altitude errors.

2.4.1.6 Uncoordinated Flight. Even though the weapon is released at planned airspeed, release height, and dive angle, uncoordinated flight at the time of release will produce an impact error. The most common errors encountered are:

1. Release in a bank (See Figure 2-36)

— Right wing down, impact right and short

— Left wing down, impact left and short

2. Skidding or sideslipping

— Ball out right, impact right

— Ball out left, impact left.

2.4.1.7 Wind and Target Motion. Wind effect on the aircraft while the pilot is tracking the pipper toward the aimpoint is as follows:

1. Right crosswind — aircraft drifts left, requiring right wing down correction to prevent overshoot.

2. Left crosswind— aircraft drifts right, requiring left wing down correction to prevent overshoot.

3. Headwind— tends to shallow dive.

4. Tailwind— tends to steepen dive.

The crosswind effects in a dive can be reduced by initially offsetting the pipper into the wind to minimize the correction required during tracking. The proper distance to offset is entirely pilot judgment based on experience. The advantages in estimating crosswind drift

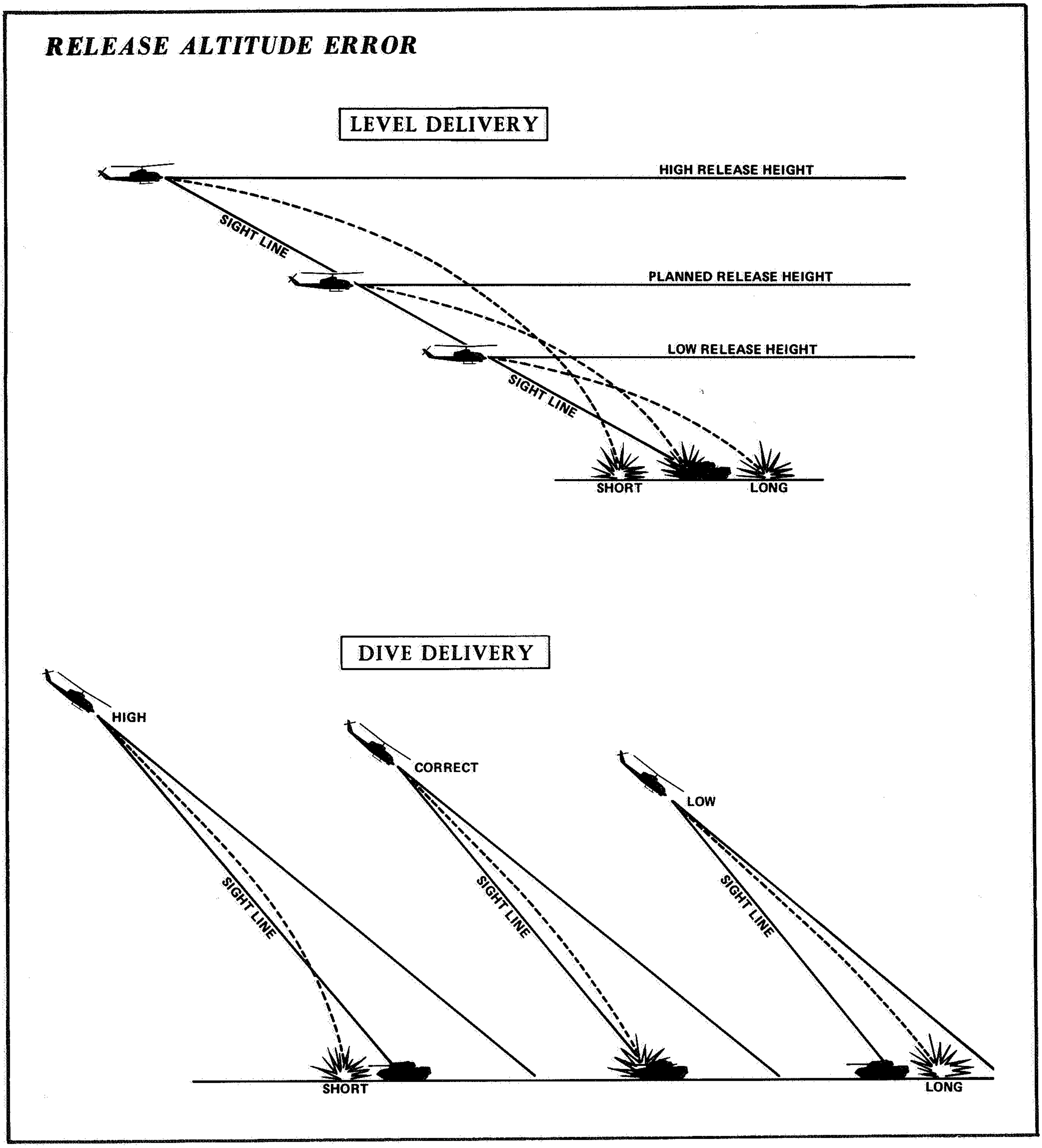


Figure 2-33. Release Altitude Error

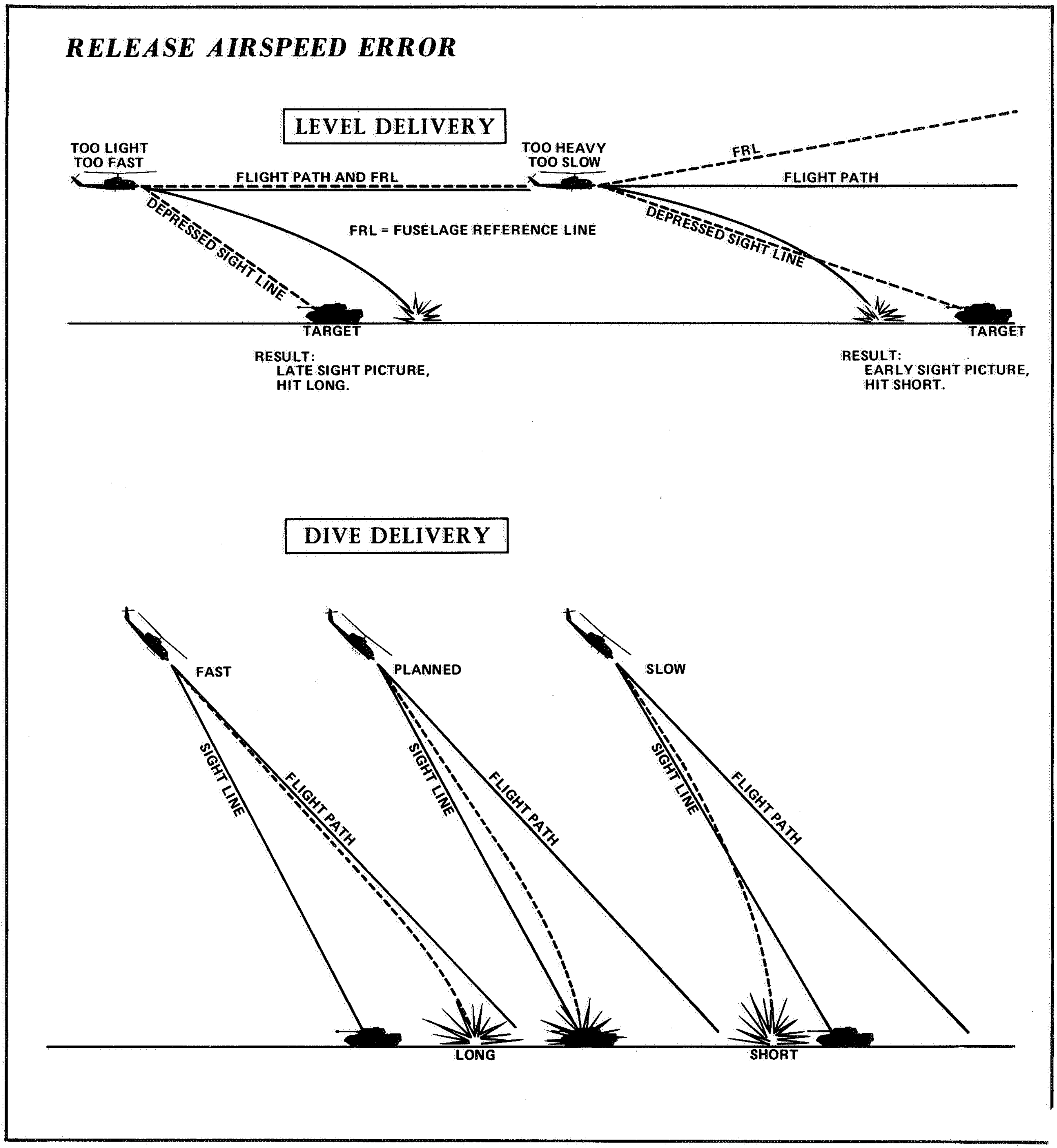


Figure 2-34. Release Airspeed Error

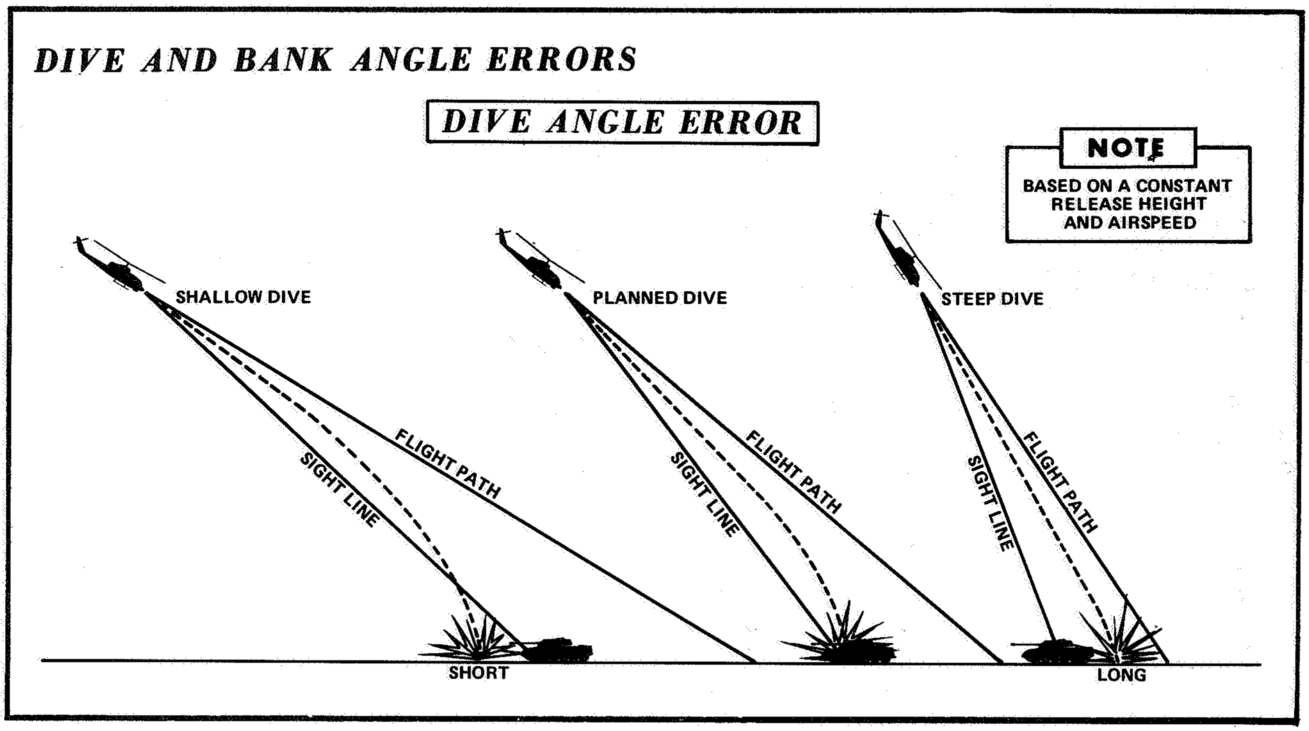


Figure 2-35. Dive Angle Errors

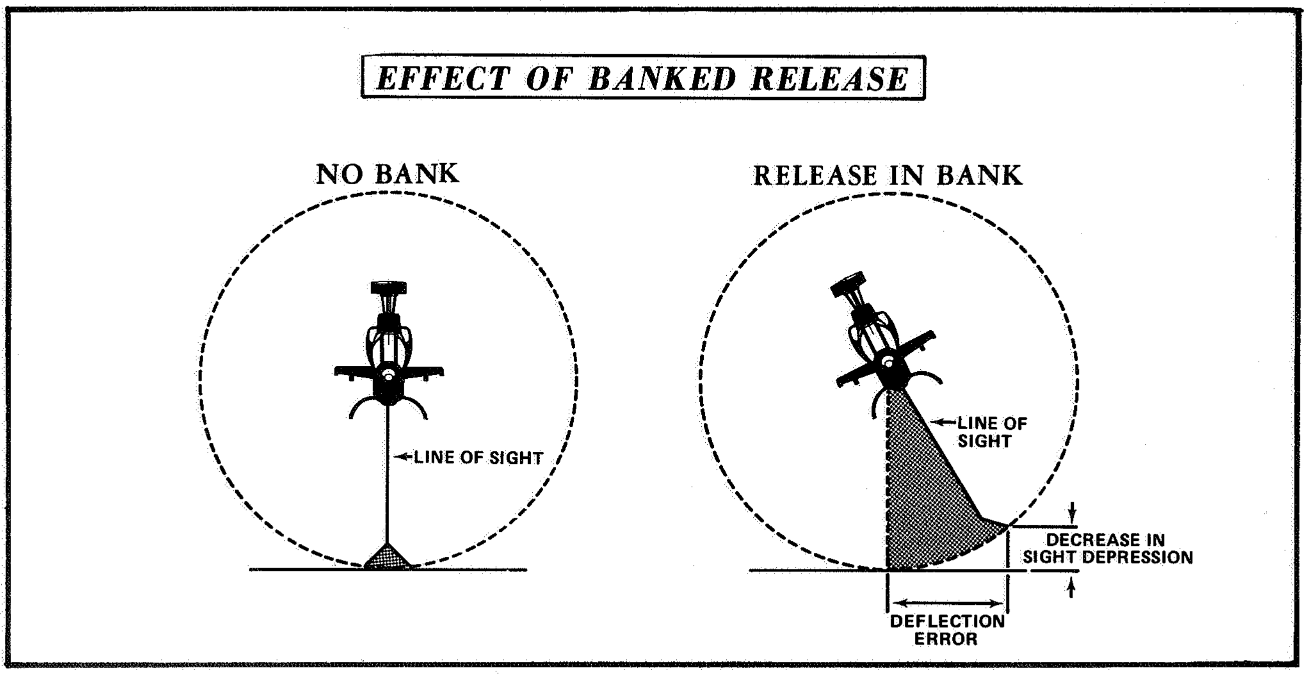


Figure 2-36. Bank Angle Errors

effect and offsetting the pipper into the wind are as follows:

1. If the offset distance is accurately estimated, the entire dive can be performed wings level, thereby eliminating one variable to permit concentration on other factors.

2. Even too little offset in the right direction is beneficial in minimizing the error caused by wind.

Regardless of the drift corrections made during the dive, the wings must be level immediately before release to eliminate the bank error factor.

The target motion is corrected for by estimating the speed and direction of target movement and predicting the position of the target at weapon impact. The predicted target position then becomes the aimpoint (Figure 2-37).

Minimum safe release altitude data are given on the sight angle charts. These flights covered dive angles of 10° to 30° and true airspeeds of 110 to 150 knots. The recovery trajectories were based on:

A/C weight (lb) = 9,000
Torque setting = 50 percent
Load factor (g) = 1.5 to 1.75 in 2 seconds (estimated)

2.4.1.8 Helicopter Down Range Travel and Altitude Loss Chart. Helicopter altitude loss and down range travel for dive delivery at 150 knots are given in Figure 2-38. This chart may be used to determine the horizontal and vertical distance traveled in a given length of time, in diving flight at 150 KTAS. As an example, the down range travel in a trimmed, 20° dive for 1.5 seconds is 358 feet; the altitude loss is 133 feet.

2.4.2 Direct Fire Adjustment/Error Analysis Procedure. To adjust direct fire, the aircrew observes the impact of the rocket and senses corrections required to hit the target. For example, the gunner senses a requirement to correct left 100 and add 500 meters. The range to the target is approximately 3500 meters. Using the rule of thumb for the 2.75-inch FFAR that a 4-1/2 mil change in elevation moves the impact point of the rocket 100 meters plus 20 mils is required to increase the range 500 meters. This correction is applied to the mil scale on the gunsight.

Two methods can be used to determine the deflection correction.

The first procedure requires that the pilot observe the lateral displacement of the rocket from the vertical centerline through the gunsight. He can mark a reference point on the horizontal hairline of the sight reticle or mentally note the point of impact. This point is the aiming reference to correct for deflection when firing subsequent engagements.

The second method requires the aircrew to compute the deflection error in mils. To determine the required correction, the rule that 1 mil will move the strike of the rocket 1 meter laterally at 1,000 meters is used. If a left 100 meters is required and the target is located at a range of 3,500 meters, a correction of 29 mils is required to hit the target.

After the lateral correction is determined, the pilot marks a reference point along the horizontal crosshair of the sight reticle or mentally notes this reference point 29 mils to the right of the pipper. Lateral corrections are always applied in the opposite direction to the required heading change so that the nose of the helicopter will move toward the target.

When the reference point is placed on the target, the correct elevation and deflection to hit the target has been applied. The next lateral adjustment is made from the reference points as just discussed.

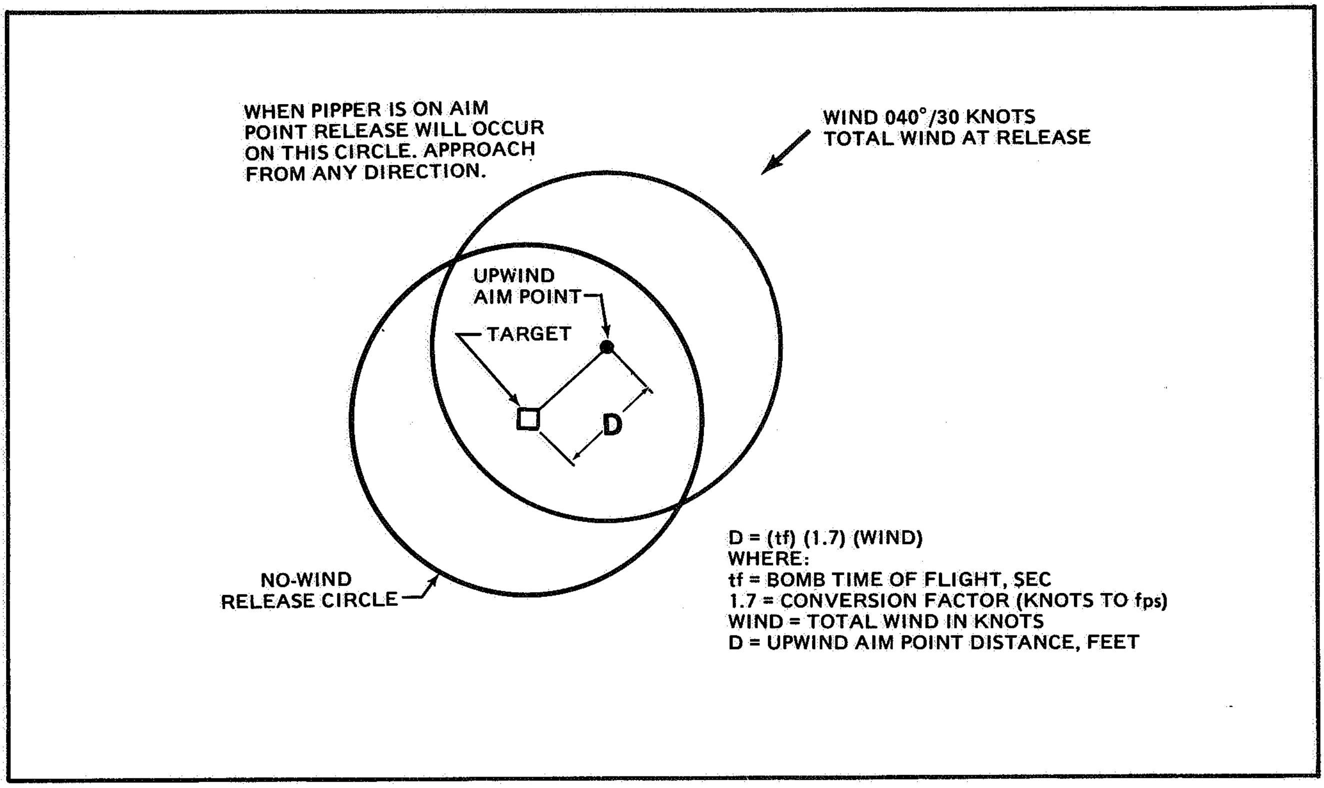

WHEN PIPPER IS ON AIM POINT RELEASE WILL OCCUR ON THIS CIRCLE. APPROACH FROM ANY DIRECTION.
WIND 040°/30 KNOTS TOTAL WIND AT RELEASE
UPWIND AIM POINT
TARGET
D
NO-WIND RELEASE CIRCLE
D = (tf) (1.7) (WIND)
WHERE:
tf = BOMB TIME OF FLIGHT, SEC
1.7 = CONVERSION FACTOR (KNOTS TO fps)
WIND = TOTAL WIND IN KNOTS
D = UPWIND AIM POINT DISTANCE, FEET

Figure 2-37. Upwind Aim Point

2.4.3 Indirect Fire Adjustment/Error Analysis Procedures (Distant Aiming Point). Corrections to adjust for indirect fire must be received from an observer. After computing the aircrew correction, the elevation and deflection required to hit the target must be determined. For example, the aircrew correction is computed to be right 100, add 400. The range to the target is approximately 3500 meters. Using the rule of thumb for range adjustment previously discussed, 16 mils is required to increase the range 400 meters (Figure 2-39).

This correction is applied to the mils scale on the gunsight. To compute the deflection correction, the aircrew must compute the mil correction using the WERM rule as previously discussed. Using this procedure, the lateral correction is computed to be 29 mils. This correction is marked or mentally noted on the horizontal crosshair of the sight reticle 29 mils left of the previous mark (Figure 2-40).

When the new reference mark is superimposed on the distant aiming point, the elevation and deflection corrections required to hit the target have been applied. Subsequent lateral adjustments are made from the new reference mark.

2.4.4 Indirect Fire Adjustment Procedures (Attitude Indicator). After receiving the observers corrections, the aircrew correction is determined to be right 100, add 800. The range to the target is 3500 meters. The unit of measurement for range adjustment is degrees; therefore, the rule of thumb that applies 1° will

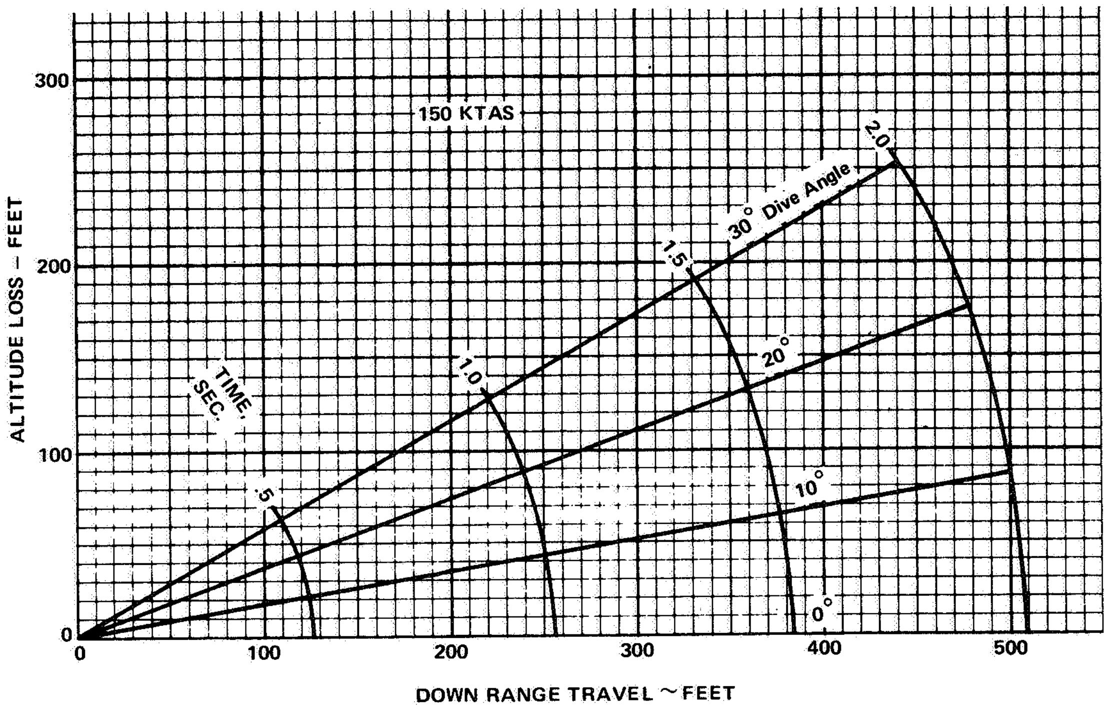


Figure 2-38. Down Range Travel Versus Altitude Loss

increase or decrease the range of the rocket 350 meters. Using this rule, the pilot must increase the pitch altitude 2° (approximately one-bar width on the attitude indicator). Because the scale on the attitude indicator cannot be read accurately, adjustments of less than 1° (350 meters) cannot be made. Another method to adjust for range is to move the helicopter either a lesser or greater distance from the initial firing point the amount required to correct for the range error and fire using the same range pitch attitude (Figure 2-41).

To determine the deflection correction, the rule of thumb that 1° heading change will move the impact point of the rocket approximately 20 meters at 1000 meters is used. In the example above, it is determined that 1° will move the impact point 70 meters (20 X 3.5). Because the scale on the heading indicator cannot be read accurately, adjustment of less than 1° cannot be made (Figure 2-42).

2.4.5 Indirect Fire Adjustment Procedures (Stable Fire). Corrections to adjust for indirect fire must be received from an observer. After receiving the observer's corrections, the aircrew correction is computed as previously discussed. For example, the aircrew correction is computed to be right 100, add 400 (Figure 2-43).

To adjust for range and lateral error, the helicopter is moved from the original firing point right 100 meters and forward 400 meters. The target is engaged from the new firing

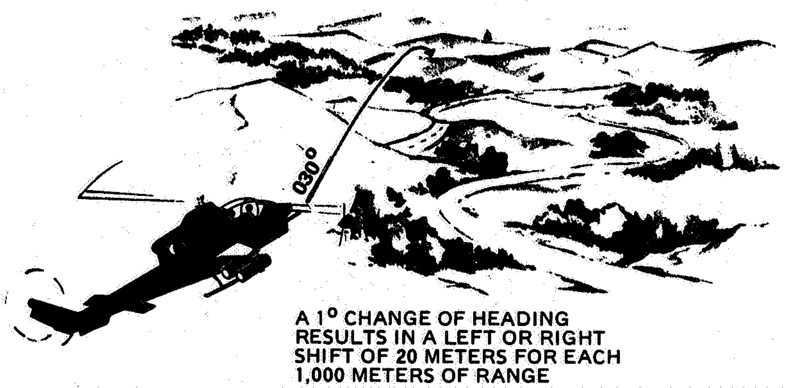

030°
A 1° CHANGE OF HEADING RESULTS IN A LEFT OR RIGHT SHIFT OF 20 METERS FOR EACH 1,000 METERS OF RANGE

Figure 2-39. Aircrew Correction

position using the original heading (Figure 2-44).

2.5 AH-1T TOW WEAPON SUBSYSTEMS

2.5.1 Capabilities and Limitations. The attack helicopter is capable of carrying eight tubular-launched, optically sighted, and wire guided (TOW) missiles. When armed with fewer missiles, a mix of different armament subsystems can be carried. The effective range of TOW missile is from 500 to 3750 meters.

Although certain conditions (high density altitude, blowing dust, and snow caused by rotorwash) may prevent the helicopter from firing the missile at hover, the primary delivery technique is hover fire.

The time of flight of the missile is determined by the distance to the target. When firing from the hover, the maximum time of flight for the missile is 21.5 seconds. The time of flight when engaging targets at ranges less than maximum range is depicted in Figure 2-45. The capability of the TOW missile to accurately destroy targets at the maximum range gives the aircrew a standoff advantage over many air defense weapons.

When the missile flies beyond the limit of the wire, impacts with the target, and experiences loss of optical or IR line of sight, automatic wirecut occurs at the launcher. If for any reason during an engagement it becomes necessary to terminate the engagement, the gunner can cut the wire by depressing the WIRECUT switch on the TOW control panel. The pilot can cut the wire by pressing the WIRECUT switch on the pilot's missile status panel or by placing the weapon control switch located on the pilot's armament control panel to the pilot PLT position. There is no mechanical device to cut the wire while in flight. If the electrical wirecut fails, the pilot should land as soon as possible and a crewmember must remove the wire. If the helicopter is flown with the wire suspended from the launcher, the wire may become entangled in the control systems. To minimize this unsafe condition, the helicopter should be flown in a slip. A safe airspeed will be determined by the effect of the wire as it streamlines behind the helicopters. The direction of the slip should be toward the side of the helicopter where the wire is suspended. This technique places the tail rotor the greatest distance from the wire as it trails from the launcher.

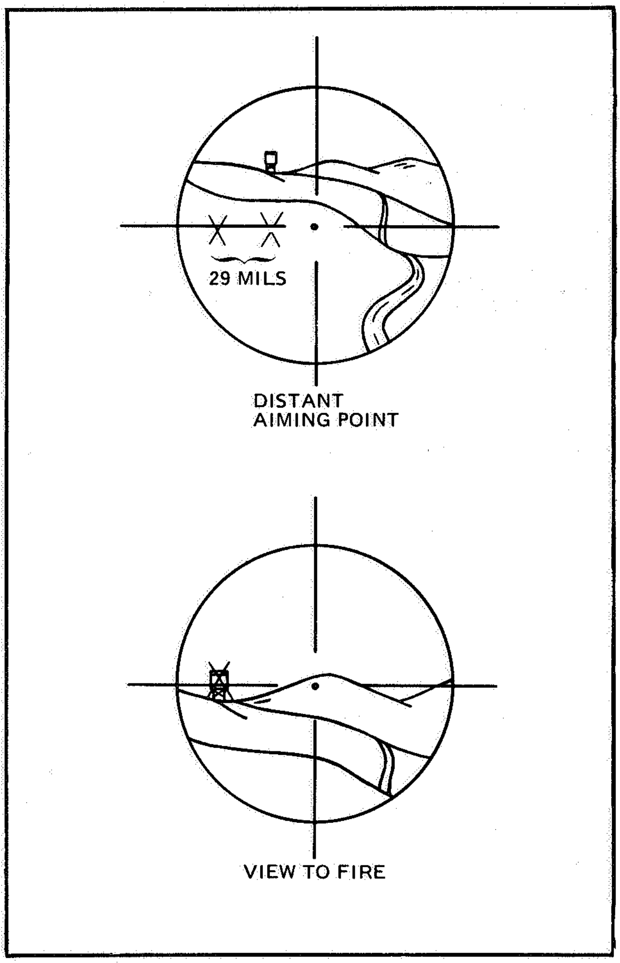


Figure 2-40. Deflection Correction Applied to Gunsight

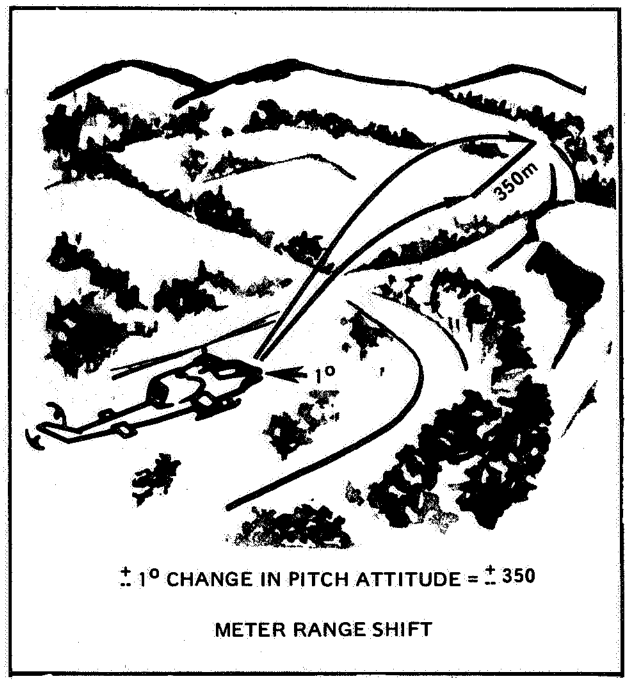


Figure 2-41. Range Adjustment

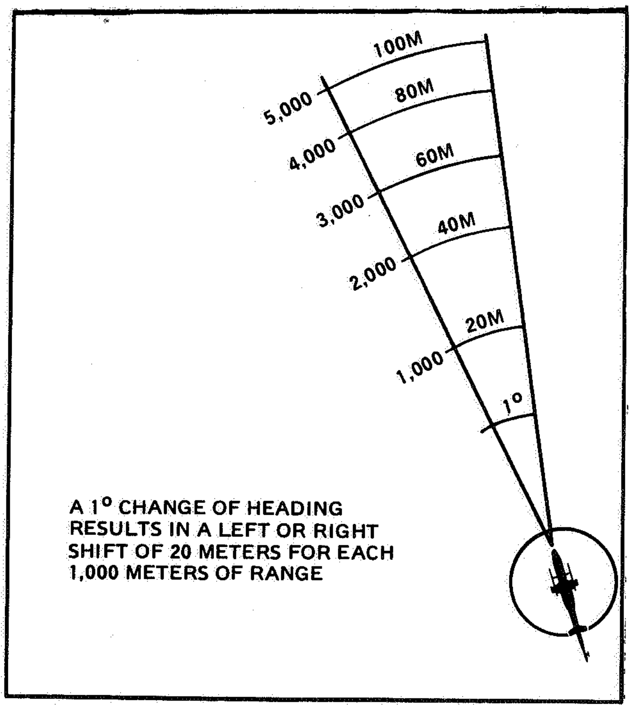

100M
80M
60M
40M
20M
1°
5,000
4,000
3,000
2,000
1,000
A 1° CHANGE OF HEADING RESULTS IN A LEFT OR RIGHT SHIFT OF 20 METERS FOR EACH 1,000 METERS OF RANGE

Figure 2-42. Deflection Correction

When firing the turret during missile engagement, vibration of the TSU will be experienced. When the trigger to fire the missile is pulled, the turret weapons will not fire for a period of 3 seconds. After this, the turret will function normally.

When the missile is fired, a danger area is created behind the helicopter. This area forms a 90° arc each side of the launcher, out to a distance of 50 meters. Additionally, a caution area extending 25 meters beyond the danger

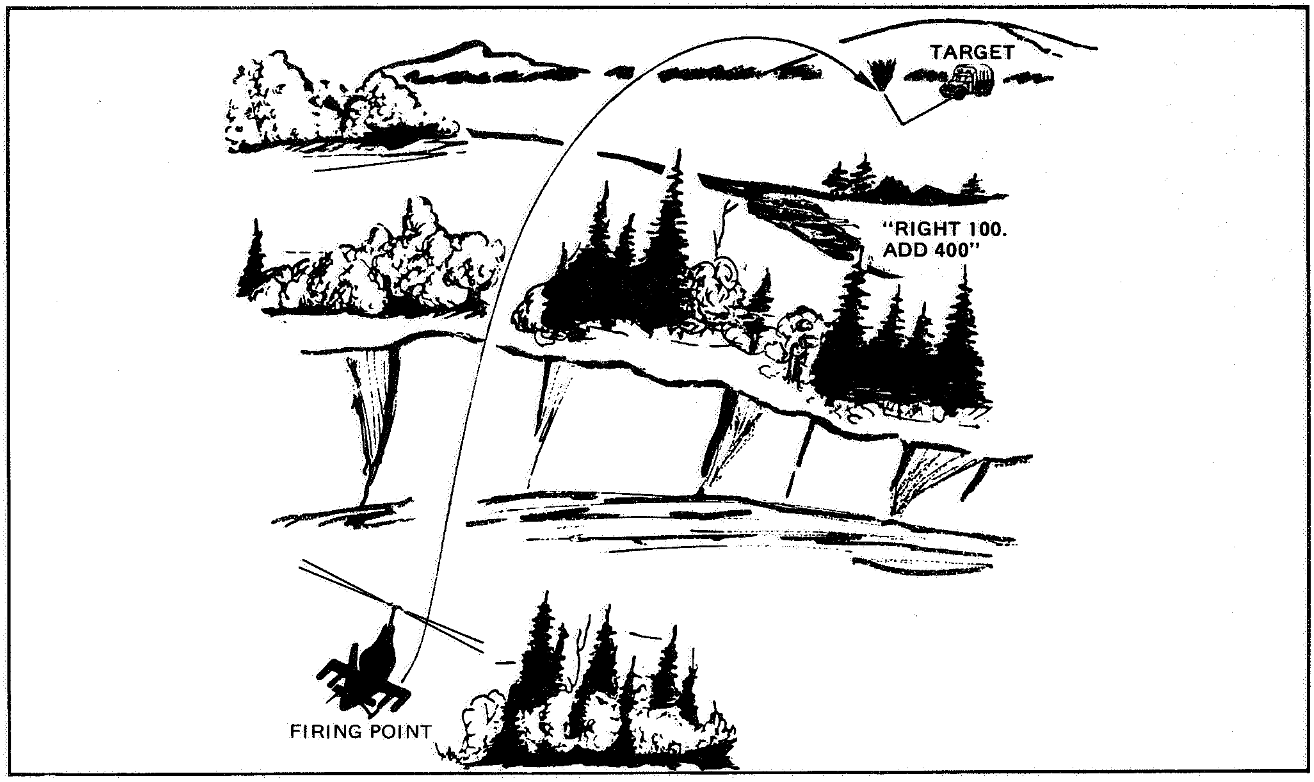


Figure 2-43. Adjustment for Indirect Fire

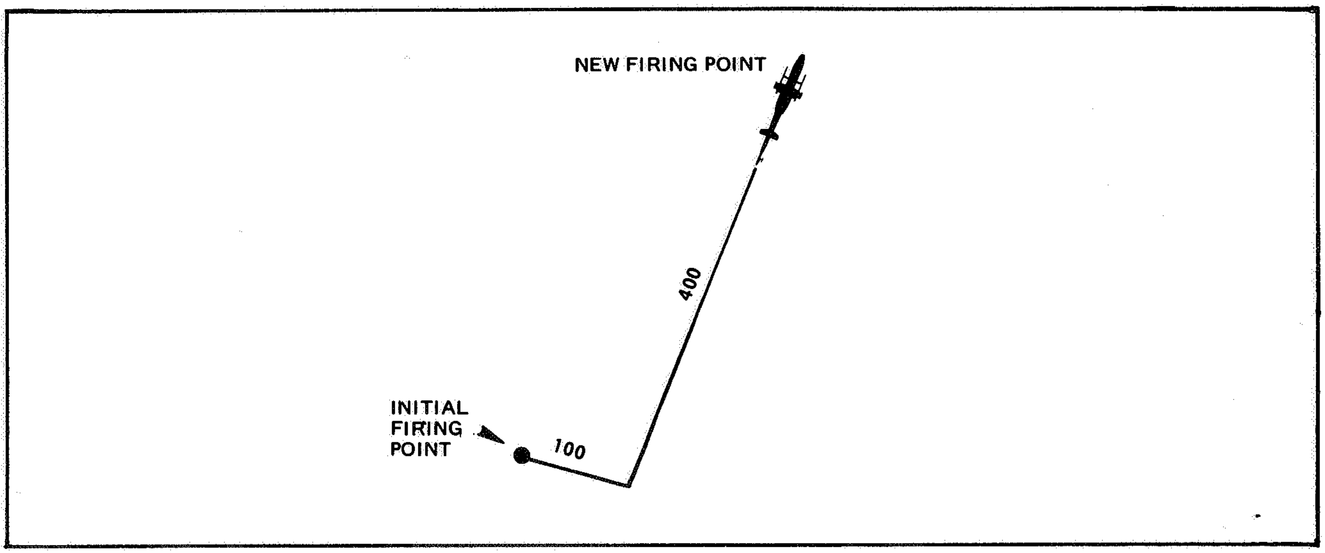
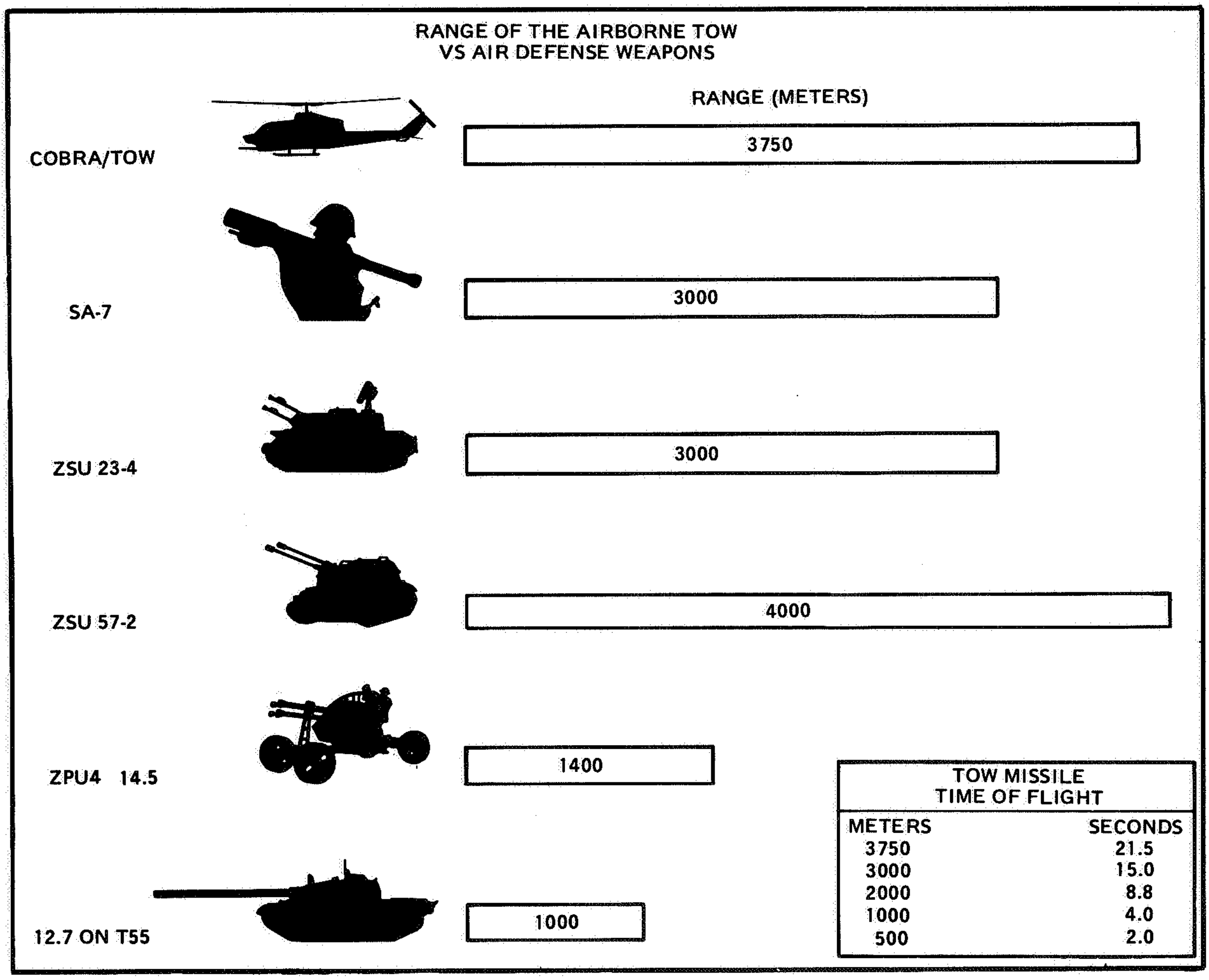


Figure 2-44. Adjustment for Range and Lateral Error

zone should be avoided. Launch signature within this area is easily recognizable from the flank; however, when observed from the front, it is difficult to detect during the day. The launch signature is more pronounced when firing in-ground-effect over the terrain that has sparse vegetation. When firing at night, the glow produced by the missile motor is easily recognizable from all directions.

The light intensity of the target is reduced approximately 70 percent when the gunner views the target through the telescopic sight unit (TSU). Normally, daylight conditions are adequate to see a target at the maximum range of the TOW missile system. Poor visibility and cloud coverage will reduce the range that the target can be seen; however, if the target can be seen with the unaided eye, it can be seen through the TSU. To Acquire targets during darkness, flares must be used to illuminate the area. Also by viewing targets through the TSU with night vision goggles (AN/PVS-5), targets can be acquired and engaged. The range at which the target can be acquired using the AN/PVS-5 will depend on the ambient light



TOW MISSILE TIME OF FLIGHT

METERS	SECONDS
3750	21.5
3000	15.0
2000	8.8
1000	4.0
500	2.0

Figure 2-45. TOW Missile Time of Flight

level. When firing the TOW missile at night, the gunners ability to track the target is impaired by the light intensity of the missile motor. This condition affects the use of the AN/PVS-5.

When engaging targets at ranges beyond 3000 meters, the missile must fly with a nose-high attitude to maintain altitude. This angle progressively increases as the velocity of the missile decreases. The effectiveness of the warhead is degraded because of the angle of impact with the target.

The probability of successful missile capture by the TSU missile tracker is affected by the boresight of the upper launcher module and telescopic sight unit (TSU).

The boresight of the helmet sight subsystem affects the target acquisition capability and the accuracy of the turret weapons. When either of these components is replaced, a portion of the boresight must be reconfirmed. Additionally, a portion of the boresight of the system is checked during each periodic inspection of the helicopter. Special equipment and training are

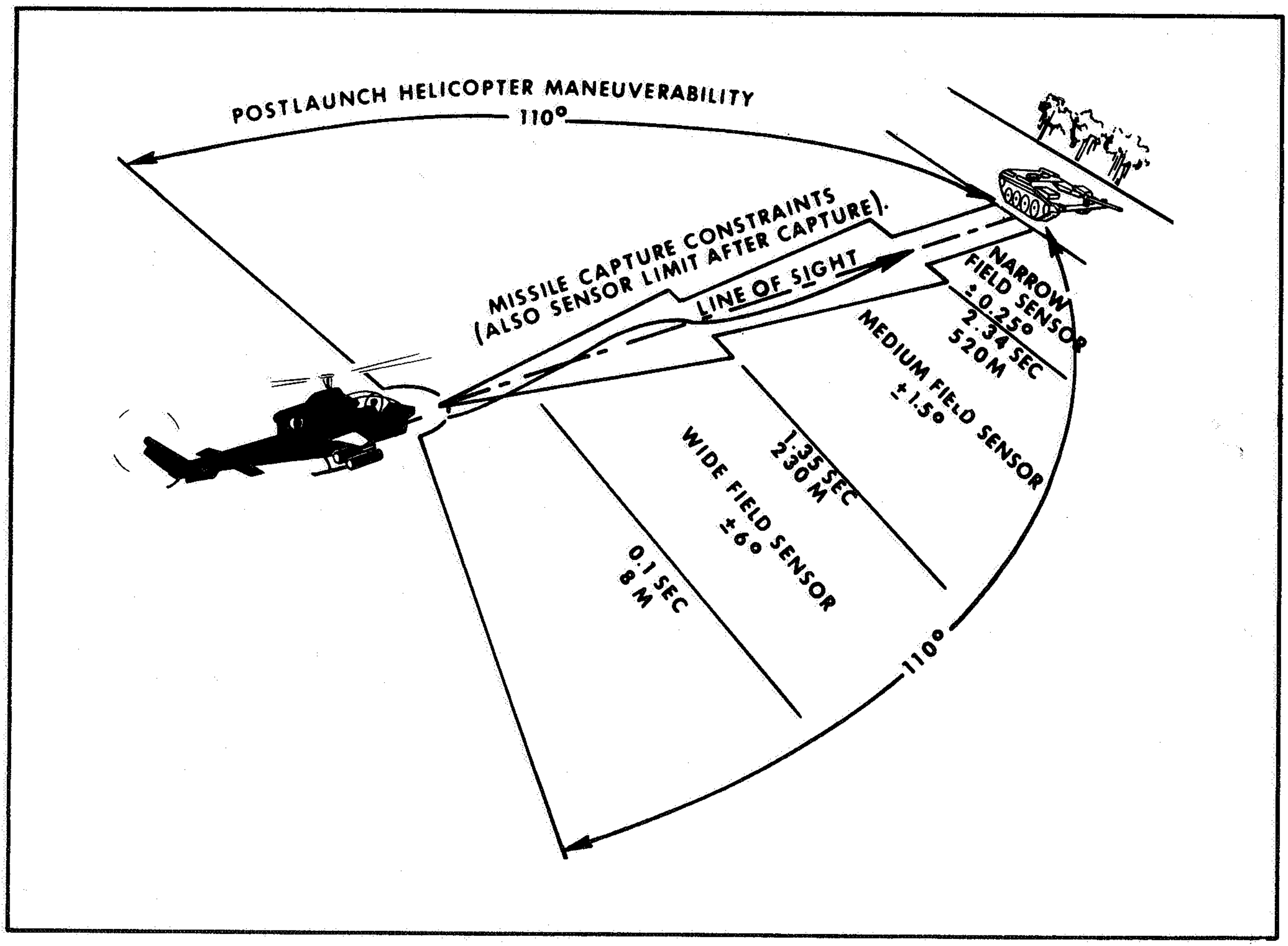


Figure 2-46. TOW Launch and Capture Constraints

required to perform a boresight. For specific information, refer to appropriate maintenance manuals.

The TOW missile system provides the gunner with a stabilized telescopic sight with low (2-power) and high (13-power) magnification. The gunner can select either power by moving the magnification (MAG) switch on the left handgrip of the telescopic sight unit (TSU). When the LO MAG position is selected, a 28° field of view can be seen by the gunner. Movement of the telescope turret (bucket) is accomplished by applying pressure to sight hand control. The bucket containing the optics can be moved in azimuth 110° left and right of the helicopter centerline, 30° elevation, and 60° depression. The sight will slue at a rate of 100° per second both in elevation and azimuth in the LO MAG mode. In the HI MAG mode, it slues at a rate of 3° per second in azimuth and elevation. When operating in the LO MAG mode, a circle is displayed on the sight reticle. This circle represents the field of view for high power magnification. It is used by the gunner to determine when he can transition to high power without losing contact with the target or in which direction and how far he must search to acquire the target after switching to HI MAG (Figure 2-52).

When operating in the high-power position, a 4.6° field of view can be seen by the gunner. The azimuth and elevation limits of the optics are the same as for the low-power mode of operation. The reticle image displayed on the TSU consists of an outer circle with a vertical and horizontal crosshair. Positioned along the horizontal crosshair is a series of vertical marks. These marks are provided to aid the gunner in estimating range to the target. The distance between the outer vertical marks is 10 mils with 2 mils separating the inner marks. At a distance of 3400 meters, the T-62 tank will fit lengthwise within the 2-mil opening. At the center of the sight reticle is an opening which is 0.4-mils wide. This area will displace a 54-inch square at the maximum range (3750 meters) of the missile and is the aiming point for the gunner when sighting on targets. Also presented on the sight reticle are three status indicators (ATTK, RDY, and GUNS). The ATTK indicator illuminates when the HI MAG position is selected and the action bar on the gunner left handgrip is depressed. At the same time the ATTK indicator illuminates on the TSU, a similar ATTK flag is presented on the pilot's steering indicator (PSI), and steering information is provided for the pilot to maneuver the helicopter within prelaunch constraints. Depressing the action bar also energizes the motion compensation circuitry which aids the gunner in tracking. The RDY flag illumiantes both on the TSU and the PSI when the helicopter is within prelaunch constraints. The GUNS indicator illuminates when the TSU/GUN position is selected on the TOW control panel and the action bar is depressed. When operating in this mode, the gunner can use the TSU to aim the turret weapons.

Incorporated into the TOW missile system is a built-in-test (BIT) feature. The electronic circuit of this test feature is activated automatically when power is applied to the TOW missile system or by depressing the BIT reset switch on the TOW control panel (Figure 1-59). During the runup of the helicopter, the pilot should place the MASTER ARM switch on the pilot's armament control panel to either the STBY or ARM position, and the gunner must position the mode selector switch on the TOW control panel to STBY TOW to operate BIT. Once the circuit has been tested, a PWR ON (power on) flag will illuminate on the annunciator of the TOW control panel. Positioning the mode switch on the TOW control panel to the ARMED position locks out the BIT circuitry, and the system will go directly to arm. This procedure should be used only as an emergency procedure. The time required to complete the BIT will vary from 30 to 120 seconds. The test circuit is incorporated into the missile guidance, stabilization, tracking, and power supply components. Continuous monitoring of the circuit occurs only in the power supply. It does not test the missile which has been selected for firing. Test circuits have not been incorporated into other components because of their high reliability, safety requirements, and the capability of the operator to observe a malfunction.

Upon recognizing a malfunction of any component that is tested by BIT prior to firing, the gunner should initiate another test. Because of the variables of the test circuit, the gunner should recycle as many as eight times to confirm that a malfunction exists before aborting the mission. In a circuit situation, an attempt should be made to determine if the malfunction is within the test circuit by firing the missile. If the missile can be captured and tracked to the target, the TOW missile system is operational and continued firings can be conducted even though a malfunction is indicated. A failure may occur in a component after it has been tested by BIT and the gunner would not be aware of the failure prior to firing a missile. If a missile is lost during launch, the gunner should depress the BIT switch to determine if a failure has occurred. Firing should be discontinued if a component failure is indicated. The TOW missile system incorporates a line replacement unit (LRU) maintenance concept. This capability allows organizational maintenance personnel to replace components (black boxes) determined to be defective by the built-in-test feature. Other maintenance on the system must be performed by intermediate level maintenance using the TOW/Airborne System Test Set (TASTS) and TOW System Evaluation Missile (TSEM).

The distance the missile can be laterally tracked by the field sensor from the optical line of sight decreases as the range of the missile from the helicopter increases. At ranges beyond 520 meters, the capture capability of the field sensor is limited to 0.25° left or right of the optical line of sight. If at any time the missile flies outside these limits for 0.5 of a second or the field sensor loses infrared (IR) line of sight with the missile for 0.5 of a second, automatic wirecut will occur (Figure 2-46).

When tracking a moving target or engaging a target while the helicopter is moving, terrain obstacles may appear between the helicopter and the missile that masks the IR emitter from the field sensor and cause automatic wirecut.

The helicopter must remain unmasked while the missile is in flight to the target. Although the time of flight of the missile is short, the additional time required by the aircrew to acquire the target and maneuver the helicopter within prelaunch constraints gives the enemy sufficient time to acquire and engage the helicopter. If within effective range of an enemy weapon system, the helicopter is vulnerable to enemy fire. Selection of a good firing position where the helicopter blends into the back- ground is important to minimize visual detection by the enemy.

Incorporated into the TSU of the TOW missile system is a stabilized sight. The pointing angle of the sight when in the track mode is independent of aircraft heading changes. The TSU will continue to point in the same direction without making inputs to the track stick regardless of the aircraft heading (within the ± 110° azimuth limits). For example, if a stationary target is engaged from a hover, the sight reticle will remain on the target while changing heading without any inputs by the gunner. If either the target or aircraft moves over the ground during the engagement, inputs to the sight hand control is required to correct for the changing line of sight between the aircraft and target.

The effect of gravity drop on the missile after it leaves the launcher is automatically compensated for prior to launch by the system setting a quadrant elevation of +1° above optical line of sight on the launcher. Additionally, the control surfaces (fins) impart an upward flight of the missile during launch. These design features enable the pilot to fire the missile with only minimum obstacle clearance, thus reducing the exposure of the helicopter. Normally, if the pilot can maintain optical line of sight with the target, it can be engaged; however, this is not

PRELAUNCH MANEUVERABILITY CONSTRAINTS		POSTLAUNCH MANEUVERABILITY CONSTRAINTS	
Heading	+2.5°	Heading	+110°
Elevation/Depression	6°	Elevation/Depression	30°/60°
Roll	5°	Roll	30°

Figure 2-47. Maneuverability Constraints

Forward Air Controller or TOW Team Leader	Gunner	Pilot
	Holding Areas	
Locate target	Coordination and planning	Coordination and planning
	Perform weapons checks	Perform aircraft checks
Target handoff	Receive target handoff	Maneuver to battle position
	Battle Positions	
Command and control	Arm weapons systems	Position helicopter in firing position
	Acquire target	Acquire target
Acquire additional targets	Track target	Maneuver helicopter to within prelaunch constraints
	Fire missile	
Recovery of downed aircrews	Track target	Maneuver helicopter within postlaunch constraints

Figure 2-48. Crew Duties TOW Missile Systems

always true. In order to engage a target, the helicopter must be within the prelaunch constraints. Terrain variation and meteorological conditions may require the pilot to maneuver the helicopter beyond the prelaunch constraints (Figure 2-47). To engage a target, the heading of the helicopter must be within 2.5° left and right, 6° in elevation and depression, and 5° in roll of target line of sight. When these prelaunch constraints are exceeded, the missile will not fire using normal procedures. The gunner can override the system by depressing the constraint override switch on the sight hand control; however, the probability of capturing the missile after launch is unlikely. Firing while in a strong crosswind is the most difficult condition that confronts a pilot. A maneuver which allows the pilot to maintain alignment over a stationary position is to slip the helicopter into the wind. An out-of-trim condition is not critical; however, the roll constraint limitations cannot be exceeded. After the missile has been launched, the helicopter is free to maneuver within the postlaunch constraints (Figure 2-47) as long as optical line of sight is maintained with the target. The postlaunch constraints are azimuth 110° left or right, 30° elevation, 60° depression, and 30° roll of the target line of sight. Although the helicopter can be maneuvered either direction after a missile has been fired, to prevent the missile wire from becoming entangled in the turret weapons and breaking, the helicopter should be maneuvered in the opposite direction from the side it was fired.

If the wire breaks while in flight, the command signal that is being received at the time will continue to be applied to the missile steering system until impact. For example, if the last signal is to climb, the missile will continue to climb until the velocity decreases and gravity causes it to descend. Wirecut can be initiated by either the gunner or the pilot at any time the missile is in flight.

Incorporated into the TOW missile system is a training aid which enables the aircrew to conduct simulated missions without firing a missile. To use the system, the missile status panel in the pilot's compartment must be removed and the gunner accuracy control panel (GACP) is installed. Additionally, an IR signal emitter must be placed on the target. The procedures for acquiring a target and the launch sequence are the same. When the gunner activates the trigger, a visual display is presented on the GACP depicting tracking error in azimuth and elevation and a scoring sequence begins. The pilot can advise the gunner which direction to correct if a tracking error exists. The scoring sequence lasts 12 seconds. At the end of this time, a readout in percentage of time the gunner maintained track on the target is presented both in azimuth and elevation/depression. The gunner's proficiency is determined by the score he achieved. The tracking sequence will continue for a total of 23 seconds; however, the gunner will not be graded after 12 seconds of the exercise. The tracking sequence may be terminated at any time by depressing the wirecut switch. When the wirecut switch is used, the engagement procedure must be initiated to activate the GACP circuit.

2.5.2 Target Acquisition. Upon receiving a target handoff, the pilot maneuvers the helicopter into the firing position, aligning it in the approximate direction to the target. Before unmasking, the gunner must place the mode selector switch on the TOW control panel to either the MAN or AUTO armed postion. The AUTO mode automatically selects the next missile to be fired and is the preferred mode of operation. The AUTO mode automatically selects the next missile to be fired and is the preferred mode of operation. Normally, both the gunner and the pilot will use their helmet sight to acquire the target. If the target is identified by the gunner, he will place the selector switch on the sight hand control (Figure 1-36) in the acquire (ACQ) position while maintaining alignment of the helmet sight on the target. Upon activation of the ACQ switch, the telescopic sight unit (TSU) slues to the target; the gunner must ensure that the TSU has slued to the target before releasing pressure on the ACQ switch. If the pilot identified the target using the helmet sight system (HSS) (Figure 1-21), the gunner must place the selector switch on the sight hand control in the TRK position and depress the PHS ACQ button. Automatically, the TSU will slue to the target and the gunner's helmet sight will retreat. Targets that are at the maximum range may be difficult to acquire using the helmet sight. When the target is acquired, the gunner must transition to the TSU after the helmet sight retracts. To acquire the target in the TSU, LOW MAG position is used. After the target is acquired in the TSU, the gunner is free to track the target using the sight hand control.

2.5.3 Engagement Sequence. After acquiring the target, the gunner applies corrections with the sight hand control to bring the target within the inner circle of the sight reticle. As the target comes within the inner circle, the gunner selects the HI MAG position and depresses the action bar on the left handgrip. Immediately, the ATTK (attack) flag on the gunner sight reticle and the pilot steering indicator illuminate. The gunner continues to track the target, keeping the aiming point on the center of mass while the pilot maneuvers the helicopter within prelaunch constraints. Both azimuth and pitch attitude constraints for prelaunch are displayed to the pilot within the pilot steering indicator (PSI). A vertical and horizontal sight line position bar displayed within the PSI provides steering information. These bars react very similar by the course deviation needle and glide slope of an ILS receiver. If the vertical bar is deflected to the left of center, the helicopter heading is right of the optical line of sight and must be corrected to the left. Likewise, if the horizontal bar is below center, the attitude of the helicopter is above the optical line of sight and the attitude must be adjusted downward.

Steering information (attitude) is also provided the pilot by the ascend/descend pointers located within the inner box of the PSI. If at any time the pointer appears, an attitude adjustment is required in the direction indicated by the pointer to position the helicopter parallel to the optical line of sight. Although it is desirable to center the sight line position bars, prelaunch constraints are satisfied when both bars are within the inner box. Once the helicopter is within the prelaunch constraints, the RDY flag on the pilot steering indicator and the RDY flag on the sight reticle of the TSU illuminate. At this time, all prelaunch requirements have been satisfied and the missile is ready to be fired. If the helicopter is maneuvered outside the prelaunch constraints after receiving a ready (RDY) indication, it will extinguish and the helicopter must be maneuvered within the prelaunch constraints to fire the missile. Roll constraints are not displayed on the PSI; however, the RDY flag will not illuminate if the helicopter is banked more than 5°. To fire the missile, the action bar and the firing trigger on the TSU left handgrip must be depressed (Figure 2-49).

2.5.4 Tracking. The probability of the missile hitting the target is primarily dependent on the gunner's ability to track a target. Failure to apply immediate and smooth corrections by the gunner is the primary cause of tracking error. As the range to the target increases, the effect of tracking error on the trajectory of the missile increases, and the probability of hit decreases. Even with a perfect track, the missile will have small deviations (normally less than 2 feet) about the line of sight; therefore, it is essential that tracking error be reduced. To reduce tracking error and increase the hit probability, the aircrew should:

1. Track the center of mass of a target.

2. Track smoothly and avoid jerky corrections (after getting on a target, smoothness and quickness are critical to get back on the center of mass).

Tracking of a moving target is aided by use of the motion compensation circuitry. When an input is made to the sight hand control with the action bar pressed, the TSU will move in the direction at a constant rate equal to the input applied. A change in tracking rate can be made by applying an input to the sight hand control. Any time the action bar is released, the automatic tracking feature is deenergized.

In addition to the tracking error, other variables exist that will affect the gunner's ability to track. For example, smoke or terrain features may momentarily block the gunner's line of sight to the target. Also, the enemy will initiate evasive maneuvers that cause the gunner to lose line of sight with the target. When the loss of a target occurs during engagement,

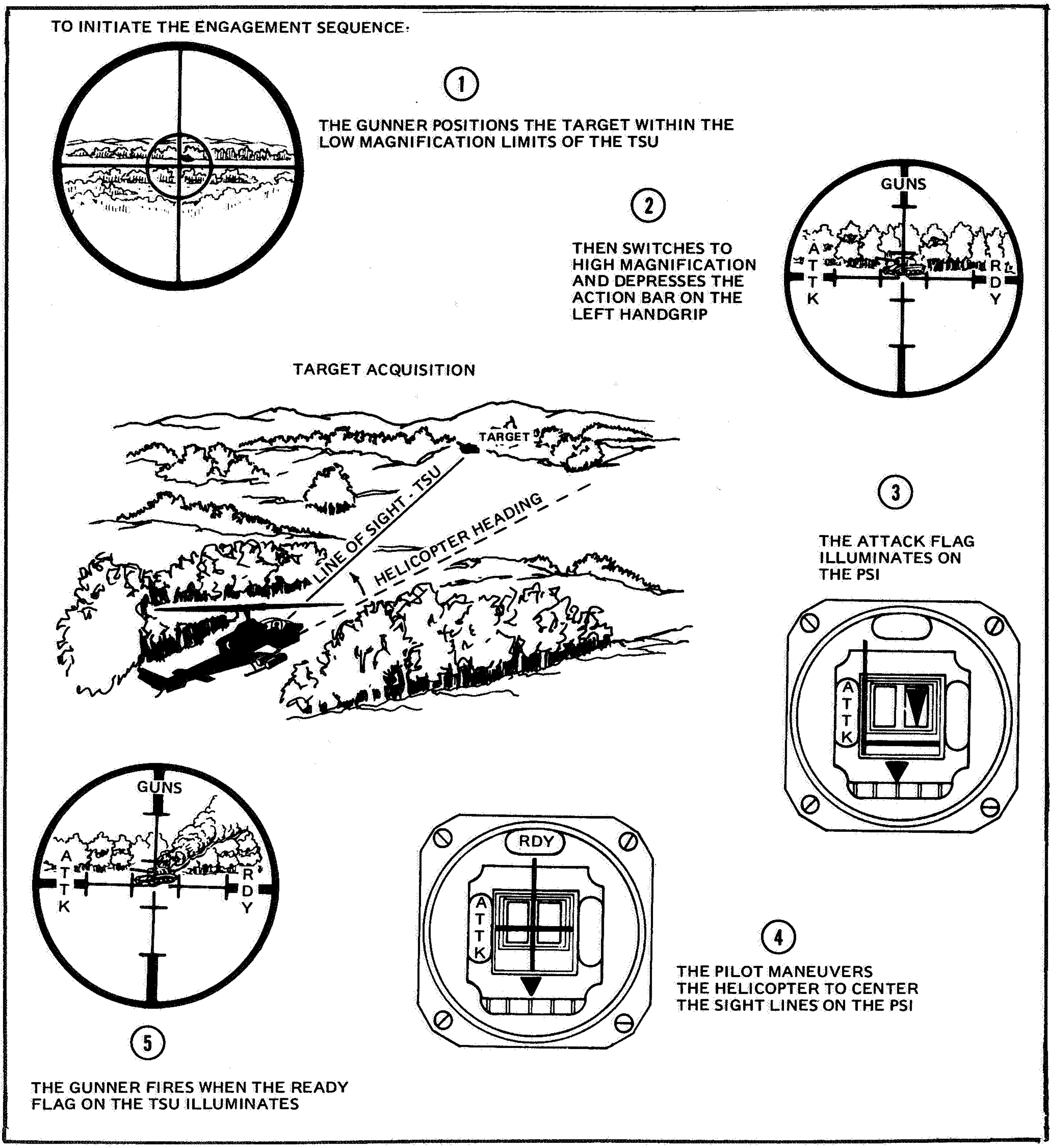

TO INITIATE THE ENGAGEMENT SEQUENCE:
①
THE GUNNER POSITIONS THE TARGET WITHIN THE LOW MAGNIFICATION LIMITS OF THE TSU
②
THEN SWITCHES TO HIGH MAGNIFICATION AND DEPRESSES THE ACTION BAR ON THE LEFT HANDGRIP
GUNS
ATTK
RDY
TARGET ACQUISITION
TARGET
LINE OF SIGHT - TSU
HELICOPTER HEADING
③
THE ATTACK FLAG ILLUMINATES ON THE PSI
ATTK
RDY
ATTK
④
THE PILOT MANEUVERS THE HELICOPTER TO CENTER THE SIGHT LINES ON THE PSI
GUNS
ATTK
RDY
⑤
THE GUNNER FIRES WHEN THE READY FLAG ON THE TSU ILLUMINATES

Figure 2-49. Engagement Sequence

the following procedures should be followed by the gunner:

1. Continue tracking at the same rate as before the target was lost.

2. Do not attempt to move the line of sight around in an attempt to see the target.

3. When the target becomes visible again, make smooth but immediate corrections to position the sight reticle on the center of mass, avoiding step-inputs.

4. If the target does not appear before the missile reaches the range to the target, the gunner should project an intercept point and track to this point until impact or the missile is beyond the range of the target.

2.5.5 Postlaunch. After the missile has been fired, a FIRE indication appears on the pilot's steering indicator. At this time, the missile has been fired and the pilot can maneuver within postlaunch constraints as long as optical line of sight to the target can be maintained. The pilot receives visual indication of the helicopter's attitude in relation to optical line of sight to the target by observing the position of the elevation/depression sight line position bar. The postlaunch constraints are depicted on the outer box.

The angular difference between the TSU line of sight and the heading of the helicopter is also indicated by the course scale azimuth pointer located below the outer box of the PSI. The horizontal scale contains azimuth angle markers spaced 55° apart. The position of the azimuth pointer left or right of center indicates the number of degrees the helicopter is displaced from the TSU and the direction the pilot must correct to center the azimuth pointer. The azimuth sight line position bar and the azimuth pointer will remain aligned as they displace laterally.

Any time the helicopter exceeds the postlaunch constraints, optical line of sight with the target cannot be maintained, and the missile will miss the target (Figure 2-50).

After the missile has hit the target or exceeded its range limitation, the fire inidcator on the pilot's steering indicator will extinguish, indicating automatic wirecut has occurred. Prior to the wirecut, the pilot should evaluate the tactical situation in order to determine if another engagement can be conducted from the same firing position. This decision is based on the enemy situation and the availability of targets that can be engaged from the firing position. If the pilot/team leader determines another engagement can be conducted, he should select the closest target to the one being engaged and maneuver the helicopter, without exceeding the postlaunch constraints, to align it with the target. Also, he must sight on the target with his helmet sight. When wirecut occurs, the gunner depresses the PHS ACQ button and the TSU slues to the target. The remaining sequence for firing the missile is the same as previously discussed. Target acquisition by the pilot during engagement reduces the time required for multiple engagements, thus minimizing the exposure of the helicopter and improving survivability (Figure 2-51).

2.5.6 Turret Firing. The turret weapons can be fired by the pilot when the gunner is firing or preparing to fire a missile if the mode select switch on the TOW control panel is positioned to STBY TOW or ARMED, MAN/ AUTO. In anticipation that the pilot may fire the turret during these conditions, the gunner armament control panel should be set for turret firing. This requires that the range estimation switch be set on the engagement range which most targets will occur and the compensation switch be placed in the COMP ON position. To ensure that the gunner maintains control of the TOW missile system, the weapon control switch on the pilot armament control panel (Figure 1-14) must be in the GUNNER position. When a target is to be engaged, the pilot sights on it with the helmet sight. Upon pressing the action bar on the cyclic, the gun turret will slue in azimuth to the point seen by the helmet sight,

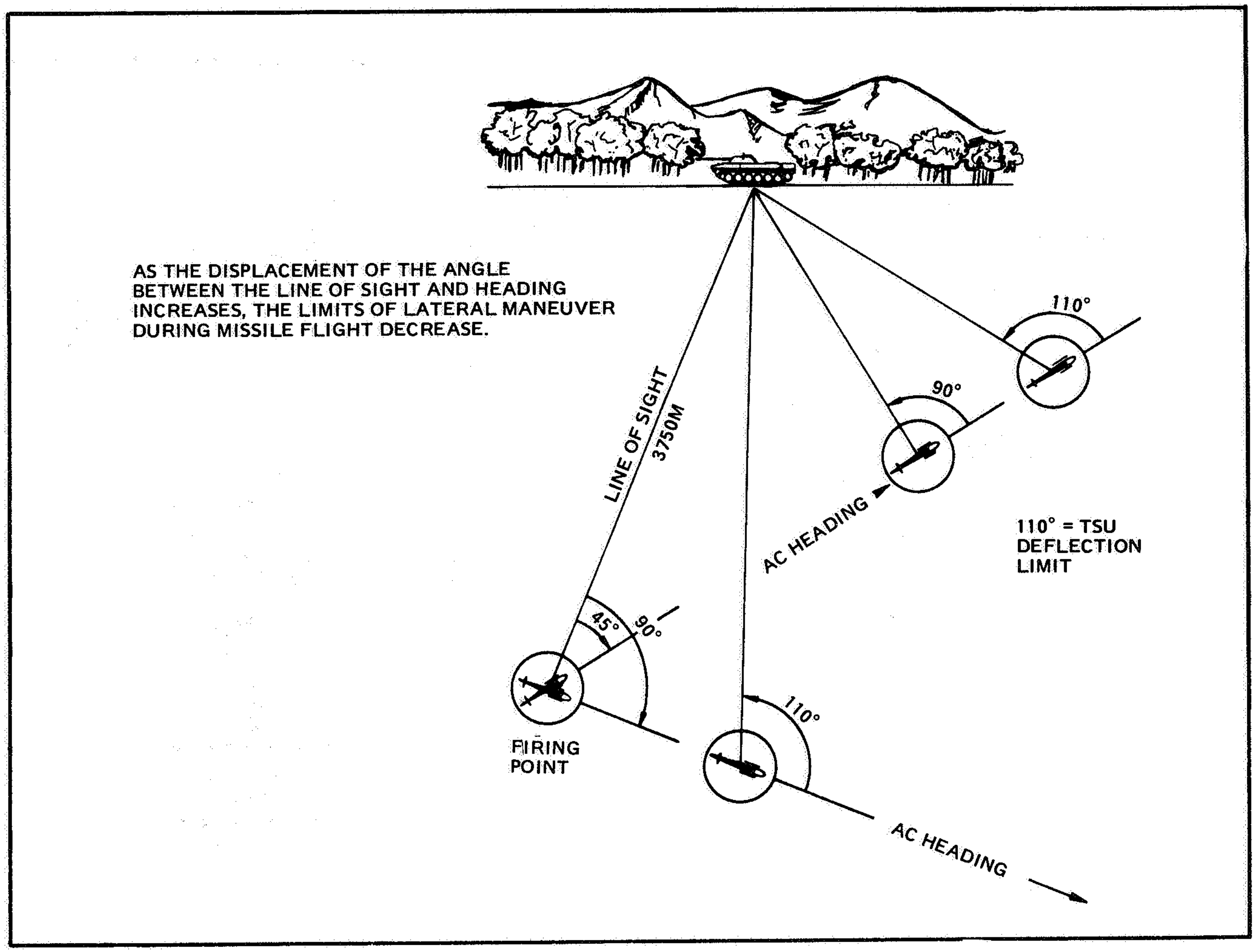

AS THE DISPLACEMENT OF THE ANGLE BETWEEN THE LINE OF SIGHT AND HEADING INCREASES, THE LIMITS OF LATERAL MANEUVER DURING MISSILE FLIGHT DECREASE.
LINE OF SIGHT
3750M
110°
90°
AC HEADING
110° = TSU DEFLECTION LIMIT
45°
90°
FIRING POINT
110°
AC HEADING

Figure 2-50. Postlaunch Maneuverability Constraints

and the gun barrel will elevate to achieve the range selected. The pilot fires the turret by pressing the turret trigger switch on the cyclic. To adjust the impact point of the projectile onto the target, the pilot repositions the helmet sight both in azimuth and elevation while pressing the action bar until the desired effect is achieved. If the pilot selects the PLT position on the pilot armament control panel to fire the turret weapon, the gunner cannot fire the missile or the turret weapons. To gain control, the gunner must activate the pilot override switch on the gunner armament control panel (Figure 1-15). Activation of the pilot override switch will not power the TOW missile system.

2.5.7 Night Tow Firing Techniques. See Chapter 10, Night and All-Weather Operations and Chapter 11, Employment of Tow Missile.

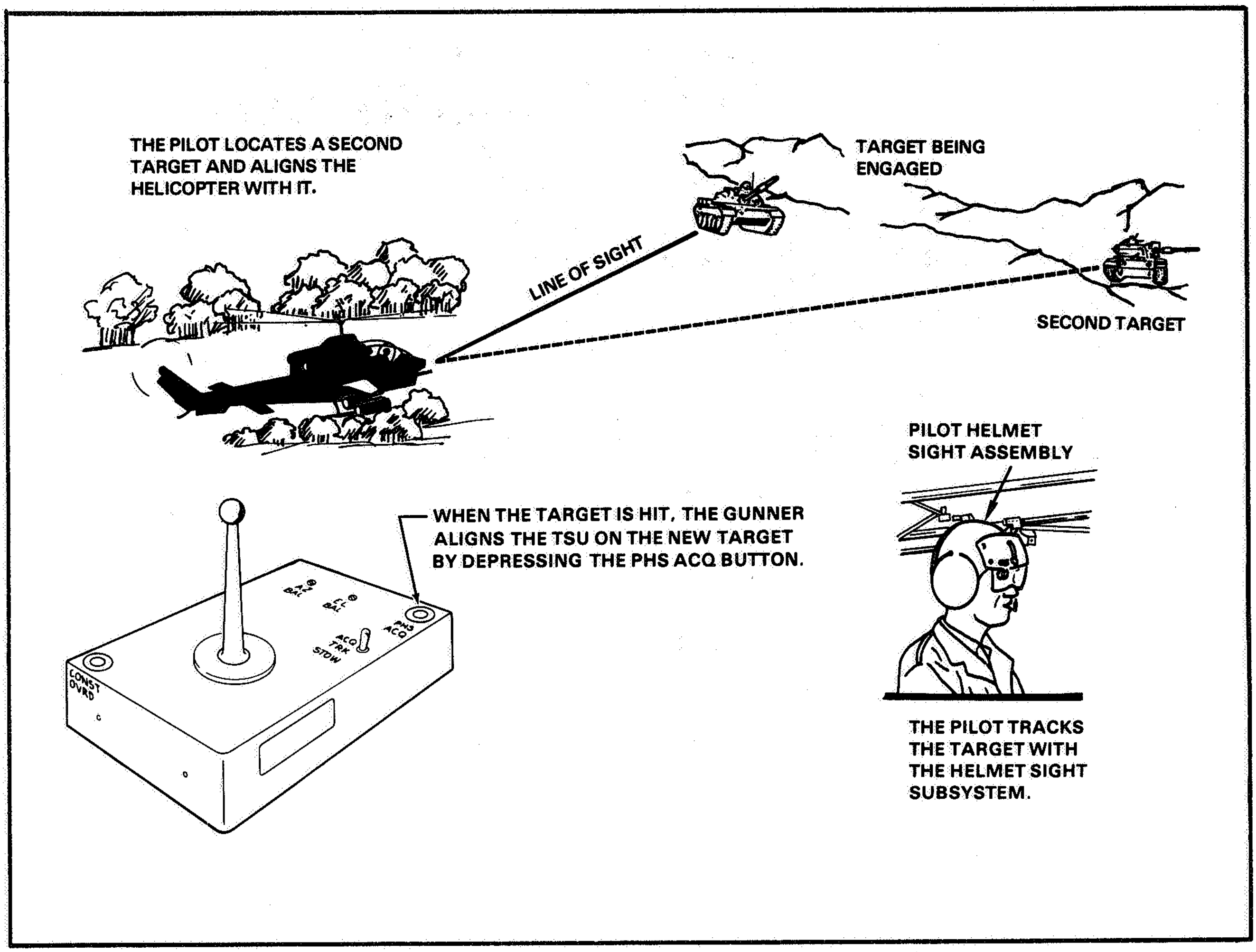

THE PILOT LOCATES A SECOND TARGET AND ALIGNS THE HELICOPTER WITH IT.
TARGET BEING ENGAGED
LINE OF SIGHT
SECOND TARGET
PILOT HELMET SIGHT ASSEMBLY
WHEN THE TARGET IS HIT, THE GUNNER ALIGNS THE TSU ON THE NEW TARGET BY DEPRESSING THE PHS ACQ BUTTON.
AZ BAL
EL BAL
ACQ
TRK
STOW
PHS ACQ
CONST OVRD
THE PILOT TRACKS THE TARGET WITH THE HELMET SIGHT SUBSYSTEM.

Figure 2-51. Second Target Engagement

CHAPTER 3

Weapons Description

3.1 MK-76 MOD 5 PRACTICE BOMB

3.1.1 Description. The Mk-76 practice bomb (Figure 3-1) is designed to simulate low-drag, free-fall weapons. It is comprised of a tear-drop-shaped, cast-metal bomb body assembly with a bore tube for installation of a signal cartridge, an Mk-1 firing pin, and a screw-in single suspension lug. Impact initiates the Mk-4 or CXU-3A/B signal cartridge which expels smoke/flame from the bore tube for impact markings. The CXU-3A/B signal cartridge is for day use only.

3.1.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), AH-1 Tactical Manual Pocket Guide, for current preflight checks.

3.2 BDU-33D/B PRACTICE BOMB

3.2.1 Description. The BDU-33D/B is an Air Force designed practice bomb (Figure 3-2) used to simulate low-drag, free-fall weapons. It is similiar in appearance and construction to the Mk-76 Mod 5 practice bomb. It is comprised of tear-drop-shaped, cast-metal bomb body assembly with a bore tube for installation of a signal cartridge, a firing pin assembly, and a screw-in single suspension lug. The firing pin assembly which is extremely sensitive to pressure has provisions for safing by the use of a safety block which is removed after loading. Impact initiates the Mk-4 or CXU-3A/B signal cartridge which expels smoke/flame from the bore tube for impact marking. The CXU-3A/B signal cartridge is for day use only.

3.2.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), Tactical Manual Pocket Guide, for current preflight checks.

3.3 MK-106 MOD 4/5 PRACTICE BOMB

3.3.1 Description. The Mk-106 practice bomb (Figure 3-3) is designed to simulate a high-drag nuclear weapon. It is comprised of a cylindrical bomb body assembly with a bore tube for installation of a signal cartridge, a screw-in firing device, and a spring-loaded retractable suspension lug. The screw-in firing device has provisions for safing by installing a safety pin. Impact initiates the Mk-4 or CXU-3A/B signal cartridge which expels smoke/flame from the bore tube for impact marking. The CXU-3A/B signal cartridge is for day use only.

3.3.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), Tactical Manual Pocket Guide, for current preflight checks.

3.4 BDU-48/B PRACTICE BOMB

3.4.1 Description. The BDU-48/B practice bomb (Figure 3-4) is designed to simulate high-drag, configured Mk 80-series LDGP bombs and DSTs. It is similiar in appearance and construction to the Mk-106 Mod 5 practice bomb. Its additional weight provides for a more stable release, better trajectory, and improved impact pattern on target. It is comprised of a bomb body assembly with a bore tube for installation of a signal cartridge, an Mk-1 firing pin, and a spring-loaded retractable suspension lug. Impact initiates the Mk-4 or CXU-3A/B signal cartridge which expels smoke/flame from the bore tube for impact marking. The CXU-3A/B signal cartridge is for day use only.

3.4.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)),

Characteristics

Length (Inches)	24.7
Body Diameter (Inches)	4.0
Weight (Pounds)	24.55
Suspension	Single lug
Explosive Components	Mk 4/CXU-3A/B signal cartridge
Identifying Marks	Blue body with white lettering

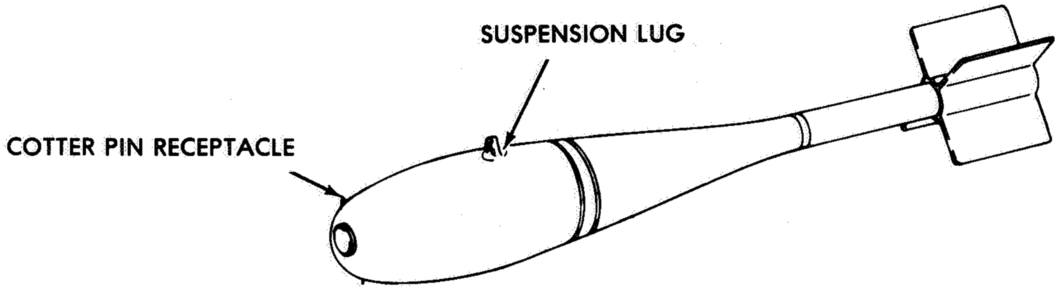


Figure 3-1. Mk-76 Mod 5 Practice Bomb

Characteristics

Length (Inches)	23.19
Body Diameter (Inches)	4.0
Weight (Pounds)	25.0
Suspension	Single lug
Explosive Components	Mk 4/CXU-3A/B signal cartridge
Identifying Marks	Blue body with white lettering

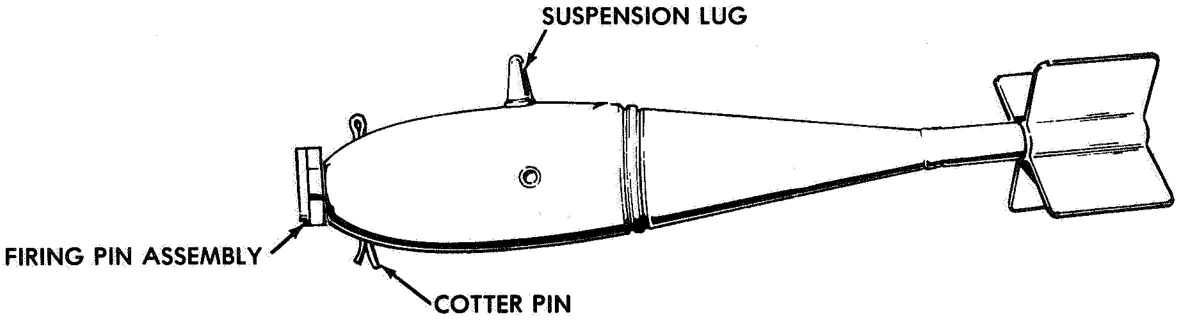


Figure 3-2. BDU-33D/B Practice Bomb

Characteristics

Length (Inches)	21.12
Body Diameter (Inches)	3.87
Weight (Pounds)	5.13
Suspension	Single lug
Explosive Components	Mk 4/CXU-3A/B signal cartridge
Identifying Marks	Blue body with white lettering

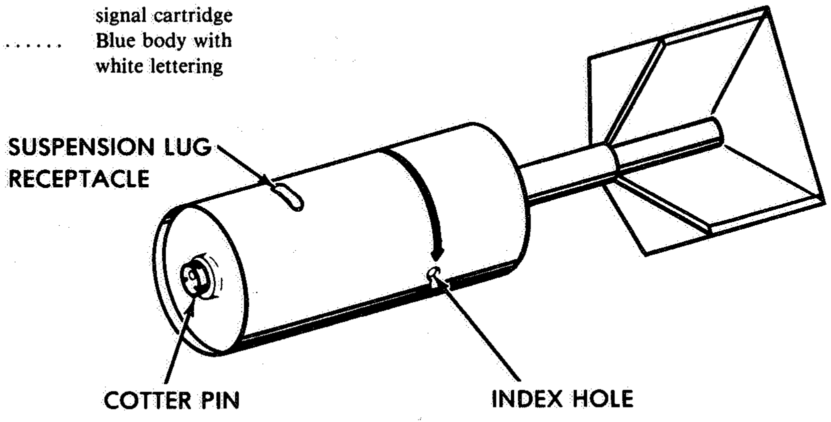


Figure 3-3. Mk-106 Mod 5 Practice Bomb

Characteristics

Length (Inches)	21.0
Body Diameter (Inches)	4.0
Weight (Pounds)	10.0
Suspension	Single lug
Explosive Components	Mk 4/CXU-3A/B signal cartridge
Identifying Marks	Blue body with white lettering

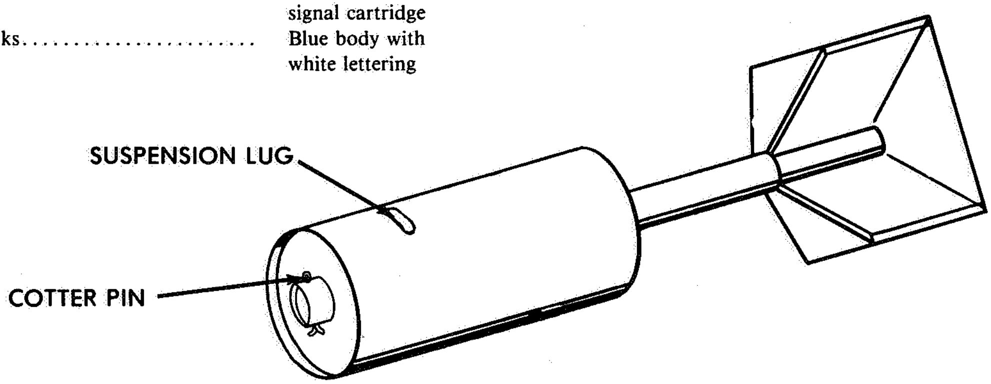


Figure 3-4. BDU-48/B Practice Bomb

Tactical Manual Pocket Guide, for current preflight checks.

3.5 A/A 37B-3 (PMBR)

3.5.1 General. The A/A 37B-3 (PMBR) is a removable auxiliary rack designed to carry up to six practice bombs, flares, or float lights. The rack (Figure 3-5) consists of a body assembly and six release assemblies. The body assembly consists of a main structural member with a nose fairing, internal electrical cabling to the release assemblies and aircraft, and an aluminum bar with provisions for 14- or 30-inch lug suspension. A release station selector dial, a mode selector switch, and a FIRE-SAFE switch are located in the tail of the rack. Only the station selector dial is operational. Each of the six release assemblies has a single store suspension hook, two integral sway braces, and access holes for rack relatching, sway brace tightening, and manual release.

3.5.2 Description. The station selector is preset to the station to be released first. PMBRs have no bomb arming solenoids and if arming wires are required, they must be positively rigged. The hook on the rack is opened by a solenoid actuated by an electric pulse from the 28 vdc of the aircraft. The store falls away by gravity drop. There is no store sensing capability and empty stations are not automatically by-passed. Stores cannot be safe jettisoned.

3.5.3 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), AH-1 Tactical Manual Pocket Guide, for current preflight checks.

3.6 MK-77 MOD 2/4 FIRE BOMB

3.6.1 Description. The Mk-77 Mod 2/4 fire bomb (Figure 3-6) is a thin-skinned, unstabilized container filled with a gelled fuel (fire bomb mix). Lack of stabilizing fins ensures that it tumbles, impacts, and ruptures in a trajectory which should maximize the dispersal of the 71 gallons of fire bomb mix. Fuzes/initiators are normally used to ignite the combustible mix. Ignition of the dispersed mix can also be accomplished by incendiary/tracer ammunition or various rocket warheads.

Note

Fuzing of fire bombs is *not authorized* because of the slow AH1 aircraft delivery speeds.

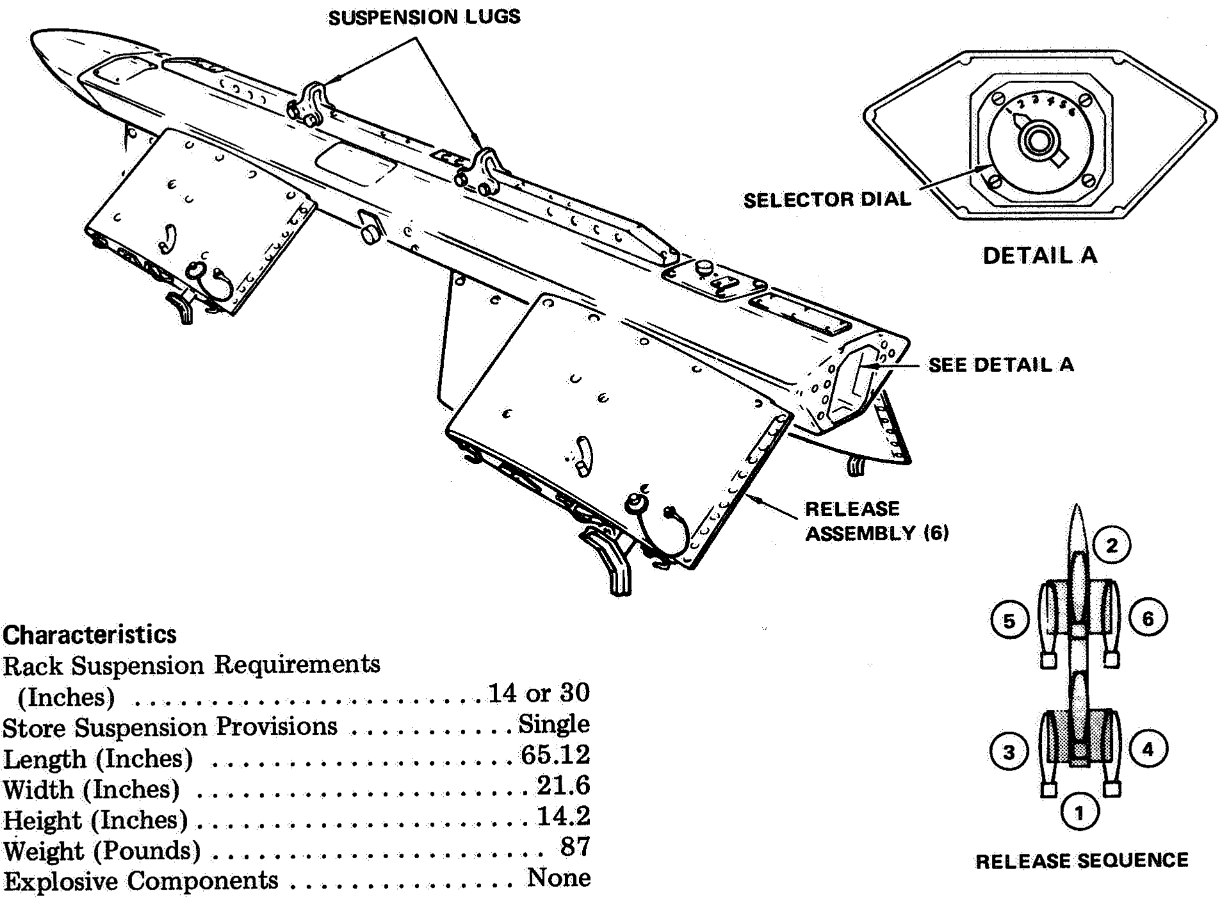
The Mk-77 Mod 2 filler holes are at the 12 o'clock position, and the Mod-4 filler holes are located 31° down the side of the container.

The elliptical splash pattern at impact is dependent on delivery speed and weapon release angle. Slow-speed delivery splash pattern data is presently not available. Fire bombs are most effective when released in pairs at dive angles less than 30° where the bombs impact short of the target by at least one-half the effective pattern length. Higher than 30° releases or extremely low delivery speeds will increase weapon impact angles and decrease the burn pattern area. Temperature at the center of the burning pattern is approximately 1,300 °F.

WARNING

- The top of the ignited mix fireball reaches approximately 250-feet AGL with a burn duration of 15 to 30 seconds. Initiating aircraft should take appropriate maneuvers.
- Loaded fire bombs must be delivered. They are not to be emptied and reused because of residual explosive vapors.

Refer to the External Stores Limitations Table for carriage and release restrictions.



Characteristics

Rack Suspension Requirements (Inches)	14 or 30
Store Suspension Provisions	Single
Length (Inches)	65.12
Width (Inches)	21.6
Height (Inches)	14.2
Weight (Pounds)	87
Explosive Components	None

Figure 3-5. PMBR Rack

3.6.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), Tactical Manual Pocket Guide, for current preflight checks.

3.7 CBU-55A/B, -/B FUEL-AIR EXPLOSIVE BOMB CLUSTER (FAE)

3.7.1 Description. The CBU-55A/B, -/B FAE (Figure 3-7) is designed as a free-fall unguided weapon to be carried on low-speed aircraft that can be used against a variety of targets. It is effective against defensive positions, light material targets, clear foliage, booby-trapped areas, and for clearing helicopter landing zones. The primary damaging mechanism is the relatively long duration of overpressure, roughly equivalent to three Mk-82 (500-pound) bombs.

Both Mods (-A/B, -/B) of the CBU-55 FAE are received in an all-up round configuration and consist of a SUU-49 A/B or -B dispenser, FMU-83/B mechanical time fuze which opens the dispenser at a preselected time, and three BLU-73A/B or -/B FAE bomb canisters. The CBU-55A/B FAE is an improved version

Characteristics	MOD 2	MOD 4
Length (Inches)	92.5	81.2
Diameter (Inches)	18.6	18.6
Weight (Pounds)	520.0	520.0
Suspension (Inches)	14.0	14.0

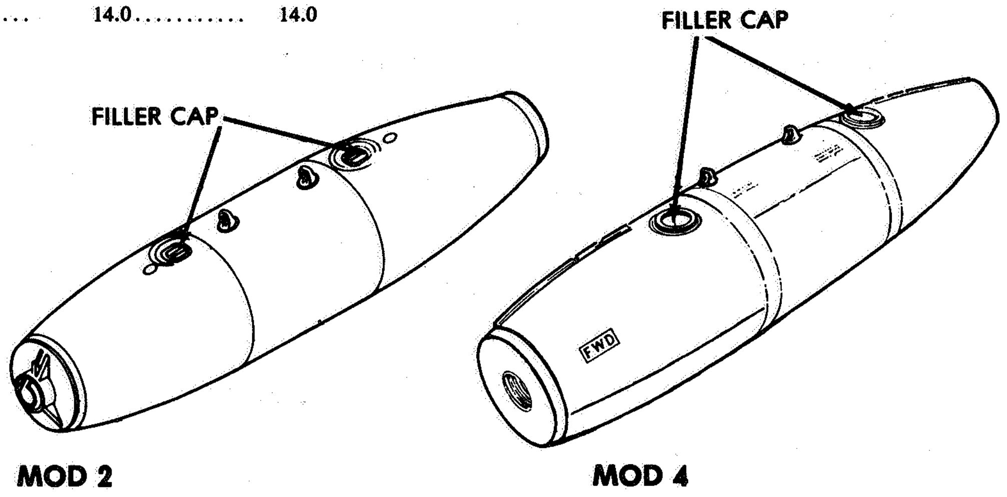


Figure 3-6. Mk-77 Mod 2/4 Fire Bomb

of the CBU-55/B. Operationally, they are identical.

3.7.2 SUU-49A/B, -B Dispenser. The SUU-49A/B, -/B dispenser is an aluminum aerodynamically shaped cylinder equipped with a nose fairing, strong back, hard shell support area, fuze arming wire, four folding fins, a removable rear bulkhead, and an explosive communication link assembly. The Mod A/B dispenser also has a thruster mechanism which allows deployment of the two upper fins after release. After release, the fuze functions at its preselected time initiating the explosive communication link and the mild detonating charge which removes the rear bulkhead assembly. Removal of the rear bulkhead assembly causes extraction and deployment of the stabilizer (drag parachute) attached to the aft BLU-73 bomb. Drag forces on the stabilizer extracts the aft bomb and subsequently each bomb canister.

A fuze arming wire is installed in a conduit that is slotted (Mod A/B) at various intervals to allow positioning of the arming wire extractor to correspond with the placement of the arming solenoids on different suspension equipment. Mod A/B also has a thruster mechanism arming wire which is positive armed to the suspension equipment when used. The fuze arming wire extractor for the Mod B is fixed and not adjustable. Some aircraft configurations require that certain fins be deployed during loading. Both Mods of the dispenser allow for manual deployment of all four fins.

WARNING

CBU-55 Mods are not authorized for shipboard use. FMU-83/B fuzes will arm at release speeds of 75 KIAS and do not meet established safety standards.

3.7.4 BLU-73A/B, -/B Fuel-Air Explosive Bomb Canister. The BLU-73 Mods FAE bomb canister is a steel cylinder containing

Characteristics	CBU-55A/B, -B
Length (Inches)	90.5
Diameter (Inches)	14.0
Loaded Weight (Pounds)	512.0 - 520.0
Suspension (Inches)	14.0
Number of Bombs	3

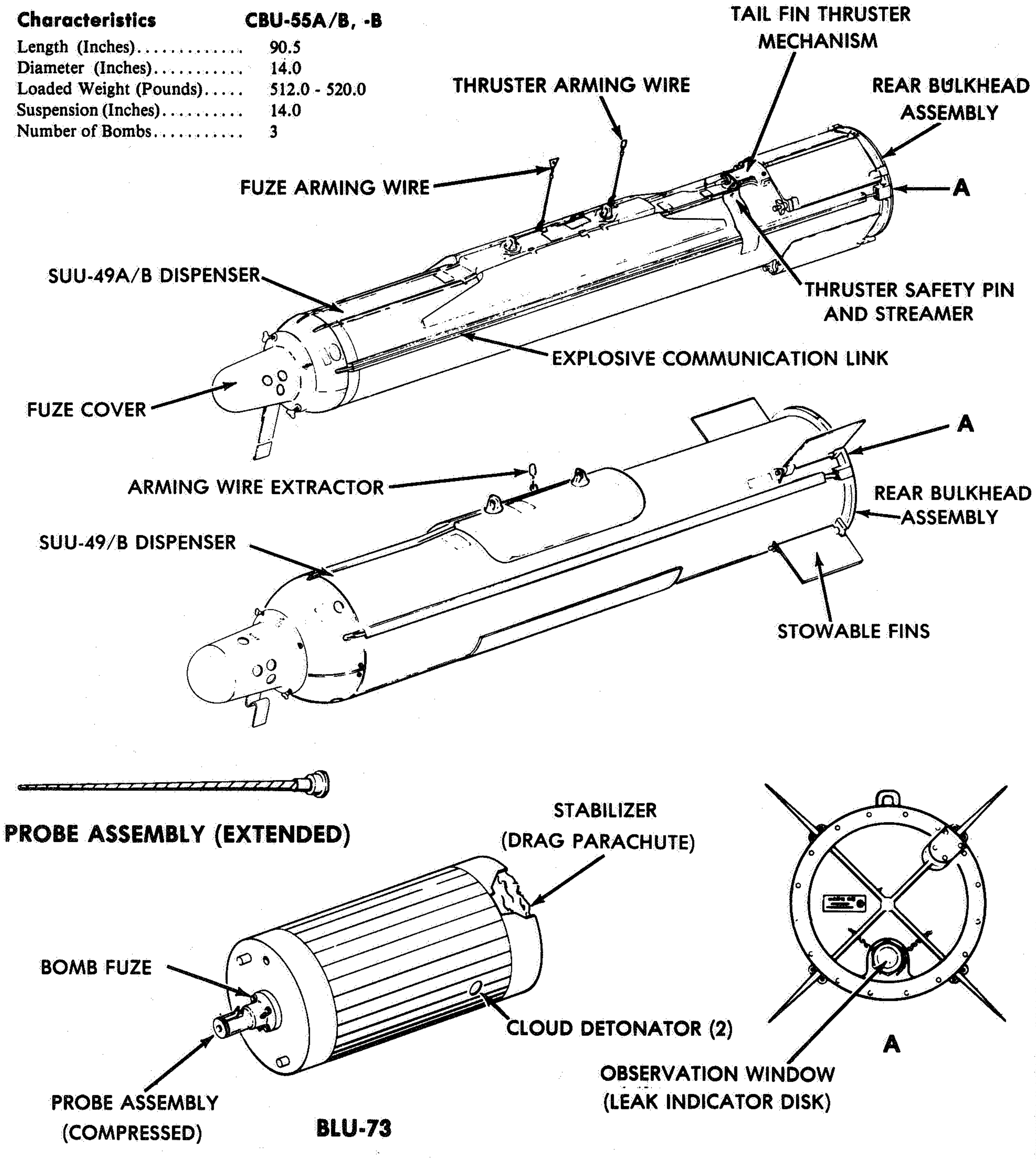

TAIL FIN THRUSTER MECHANISM
THRUSTER ARMING WIRE
REAR BULKHEAD ASSEMBLY
FUZE ARMING WIRE
A
SUU-49A/B DISPENSER
THRUSTER SAFETY PIN AND STREAMER
EXPLOSIVE COMMUNICATION LINK
FUZE COVER
A
ARMING WIRE EXTRACTOR
REAR BULKHEAD ASSEMBLY
SUU-49/B DISPENSER
STOWABLE FINS
PROBE ASSEMBLY (EXTENDED)
STABILIZER (DRAG PARACHUTE)
BOMB FUZE
CLOUD DETONATOR (2)
A
OBSERVATION WINDOW (LEAK INDICATOR DISK)
PROBE ASSEMBLY (COMPRESSED)
BLU-73

Figure 3-7. CBU-55A/B, -/B, Fuel-Air Explosive Bomb Cluster (FAE)

ethylene oxide. A contact fuze is located on the forward bulkhead and a stabilizer (drag parachute) on the aft bulkhead. A burster charge extends through the center of the canister and, when initiated by the contact fuze, it disperses the ethylene oxide creating an aerosol cloud. Two cloud detonators installed in the sides of the bomb canister, opposite each other, are also ejected from the canister and detonate the aerosol cloud after a preset delay, creating the high overpressure.

The bomb canisters have a degree of target discrimination which allows them to penetrate light foilage without detonating. The fuze operational cycle commences when the bomb canister first enters the airstream. An extenable standoff probe extends immediately (Mod B), or after 2.2-seconds (Mod A/B), which detonates the bomb canister 4 feet above the surface of the target. If the standoff mode fails, an inertial backup system initiates the bomb canister. Some canister fuzes have a self-destruct device which will detonate the canister burster charge 2 minutes after impact. The self-destruct feature will function in water to depths of 30 feet.

Aerosol cloud formation is most effective when the impact angle of the bomb canister approaches 90°. The inertial backup system detonates the bomb canister if the impact/speed is insufficient for normal detonation. However, overall effectiveness is considerably degraded.

3.7.5 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), Tactical Manual Pocket Guide, for current preflight checks.

3.8 FMU-83/B MECHANICAL TIME FUZE

3.8.1 Description. The FMU-83/B mechanical time fuze (Figure 3-8) is a universal dispenser fuze for slow-speed aircraft and is currently used to initiate opening of the CBU-55 FAE weapon. The fuze is received preassembled in the weapon.

Note

> To ensure BLU-73 bomb canister arming, a 2.2-second time-of-fall is required after FMU-83/B fuze functioning.

The fuze has a time setting dial which must be set prior to flight. The preflight-selectable time range is from 1.00 to 9.70 seconds in 0.10-second increments.

The time setting observation window also incorporates a visible indication of the fuze SAFE/ARM condition. A SAFE condition is the desired set functioning time superimposed on a green background. An ARM/partially ARMED condition exists when a red background is visible in the observation window. Refer to Figure 3-8 for detailed indications.

Characteristics

Type	Mechanical Time - Nose
Limit Speeds	
Max Carriage	450 KIAS
Max Release	300 KIAS
Min Release	75 KIAS
Functioning Time Range	1.0- to 9.7-seconds
Inflight Options	None
Authorized Bombs	CBU-55/B, -A/B, FAE

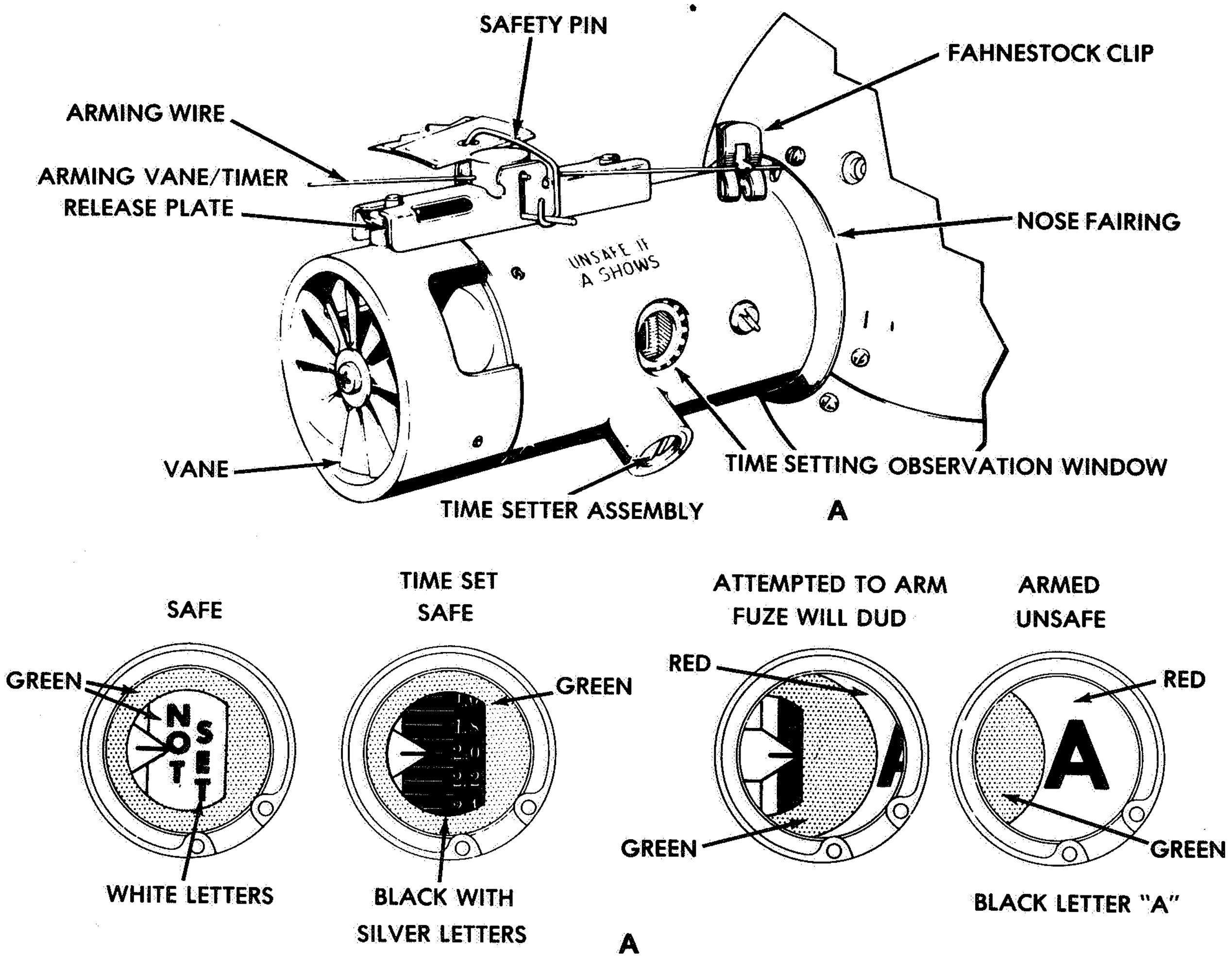


Figure 3-8. FMU-83/B Mechanical Time Fuze

3.8.2 Applications and Restrictions. The FMU-83/B mechanical time fuze will arm and reliably function at delivery speeds of 75 KIAS to 300 KIAS. Minimum release speed is 75 KIAS.

Certain early production FMU-83/B fuzes have an arrow decal on the timer-setter assembly. These fuzes can *only* be set by rotating the screw in a clockwise position in accordance with the decal. The screw on those fuzes without a decal may be rotated in either direction.

Refer to the External Stores Limitations Table for any additional restrictions.

3.8.3 Preflight Checks

1. Fuze Safe.

2. Fuze Function Time Set.

3. Safety Pin and Warning Tag Removed.

4. Arming Wire Installed in accordance with Pocket Guide/Weapons/Stores Loading Manual.

3.9 SMOKE GRENADE M8/M18

3.9.1 Description. The M8/M18 smoke grenade (Figure 3-9) used in the M118 smoke grenade dispenser is of the normally hand-dispensed type. With safety pin pulled, spoon is held in position by a retainer plate in the dispenser until ejection occurs. M18 grenades produce either blue, yellow, white, violet, red or green smoke. The M8 grenade produces white smoke only. Color of smoke produced is stenciled on the side of the M18 grenade. The M118 grenade dispenser carries up to 12 grenades that are dispensed one at a time. For additional information refer to NAVSEA SW050-AB-MMA-010/NAVAIR 11-15-7 Pyrotechnic, Screening, Marking, and Countermeasures Devices.

3.10 MK-45 MOD 0 AIRCRAFT PARACHUTE FLARE

3.10.1 Description. The Mk-45 Mod 0 aircraft parachute flare (APF) (Figure 3-10) is used for nighttime illumination of surface areas in search and attack operations. It is compatible with the SUU-44/A flare dispenser.

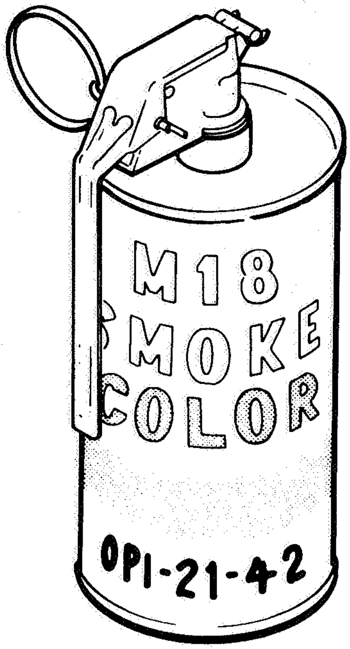
The Mk-45 Mod 0 APF provides 210 seconds of 2,000,000-candlepower illumination. The flare components include a fuze, ejection mechanism, parachute suspension system, igniter assembly, pyrotechnic candle, and an aluminum case. The fuze which controls the free-fall distance to parachute deployment and candle ejection has 15 ejection settings between 500 and 14,000 feet of fall and a SAFE setting. The desired functioning delay is selected by positioning the ejection dial to the appropriate setting.

A steel lanyard extracts the safety clip from the ejection dial and pulls the internal disconnect from the fuze mechanism as the flare is dispensed/released which initiates the delay mechanism. At the end of the preset delay, the fuze ignites the expellant which ejects the candle and parachute from the case. The shock of the deployed parachute ignites the candle by means of an igniter assembly. At candle burnout, an explosive bolt severs 10 of the 18 parachute shround lines causing the parachute to collapse, and the flare remains to free-fall to the ground thus clearing the airspace of any flare debris hazard.

CAUTION

Flares released from SUU-44/A dispensers require straight and level delivery. Check the External Stores Limitations Table for additional restrictions.

3.10.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)),



Characteristics

Height	5.68 Inches
Diameter	2.37 Inches
Weight	2.0 Pounds

Figure 3-9. Smoke Grenade M8/M18

Characteristics

Length (Inches)	36.0
Diameter (Inches)	4.9
Weight (Pounds)	28.0
Suspension	dispenser

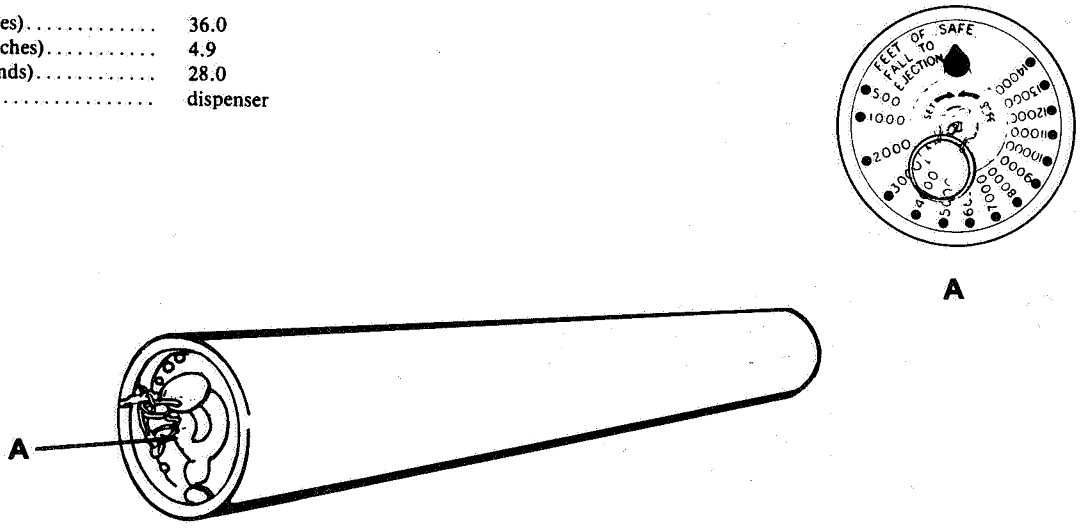


Figure 3-10. Mk-45 Mod 0 Aircraft Parachute Flare

Tactical Manual Pocket Guide, for current preflight checks.

3.11 LUU-2A/B, -B/B AIRCRAFT PARACHUTE FLARE

3.11.1 Description. The LUU-2A/B, -B/B aircraft parachute flare (APF) (Figure 3-11) is used for nighttime illumination of surface areas in search and attack operations and was designed to replace the Mk-45 APF. The two variants, A/B and B/B, are compatible with the SUU-44/A flare dispenser. Only the LUU-2B/B is compatible with the SUU-25 F/A flare dispenser.

Note

The LUU-2A/B is not authorized for shipboard operations.

The LUU-2A/B APF provides 300 seconds of 1,600,000-candlepower illumination. The flare components include a timer assembly, parachute suspension system, ignition system, and case-candle assembly. The timer which controls the free-fall distance to parachute deployment and flare ignition has 12 settings between 500 and 11,000 feet of fall and a SAFE setting position. The desired functioning delay is selected by positioning the time knob to the appropriate setting. A parachute deployment force of 98 pounds is required to initiate the candle.

The LUU-2B/B APF provides 240-seconds of 2,000,000 candle power illumination. The flare components include a timer assembly, parachute suspension system, an out-of-line igniter, and the case assembly with a tamped candle. The timer which controls the free-fall distance to parachute deployment and flare ignition has a 250 feet setting for helicopter use and 13 other settings between 500 and 11,000 feet of fall and a SAFE setting position. The desired functioning delay is selected by positioning the timer knob to the appropriate setting. A parachute deployment force of 90 pounds is required to pull the slider assembly (out-of-line igniter) into line releasing the firing pin to initiate the pyrotechnic train and candle.

A steel lanyard extracts the timer knob on both variants of the flare when dispensed/released which allows the timer clock mechanism to function. At the end of the preset delay time, a spring ejects the timer and release mechanism from the flare housing which deploys the 18-foot cruciform parachute. Initiation of the candle subsequently takes place. At candle burnout, an explosive bolt severs one of the suspension cables causing the parachute to collapse, and the flare remains to free-fall to the ground thus clearing the airspace of any flare debris hazard.

CAUTION

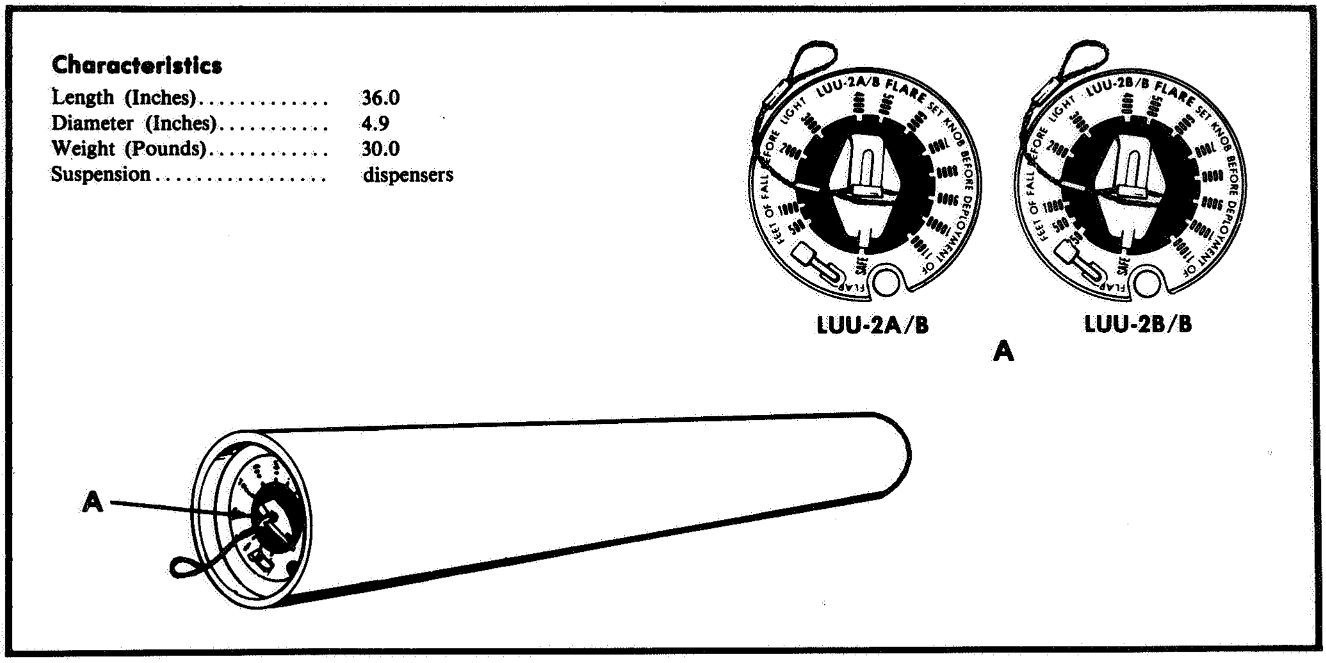
Flares released from SUU-25 F/A/-44/A dispensers require straight and level delivery. Check the External Stores Limitations Table for additional restrictions.

3.11.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), Tactical Manual Pocket Guide, for current preflight checks.

3.12 SUU-44/A DISPENSER

3.12.1 Description. The SUU-44/A dispenser (Figure 3-12) is a reusable four-tube launcher capable of carrying and ejecting rearward eight Mk-45 Mod 0/LUU-2A/B, -B/B, parachute flares.

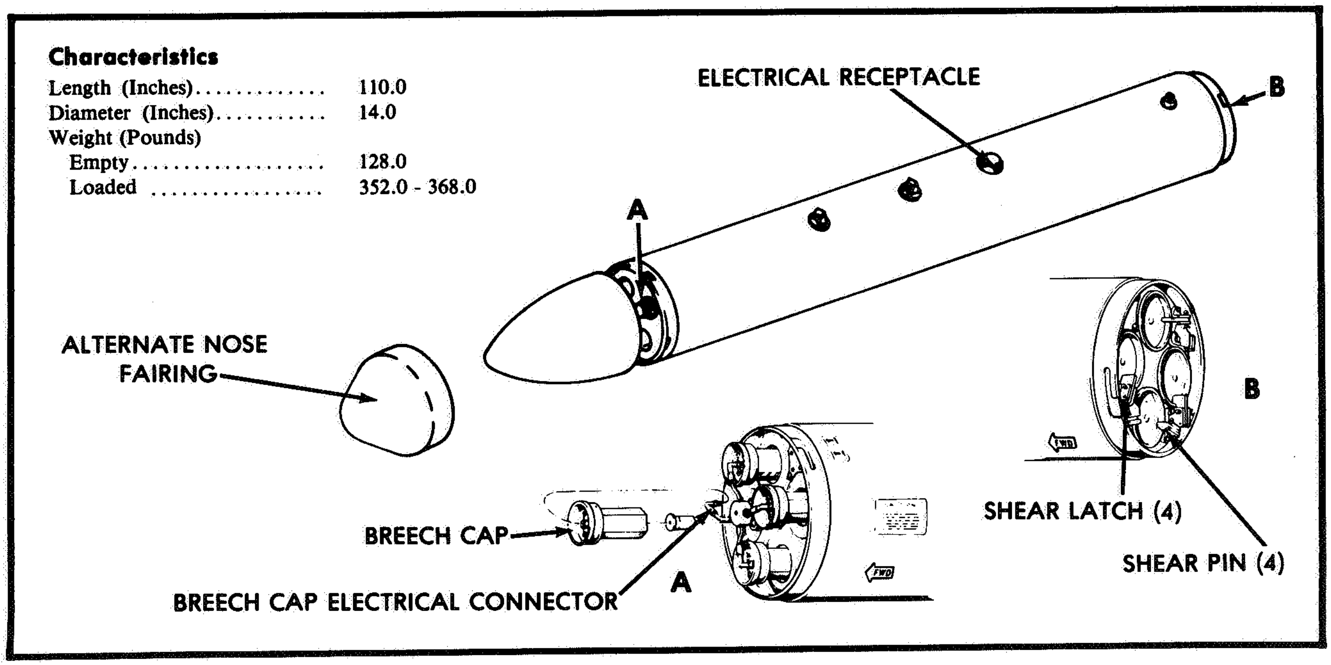
Each of the four launching tubes accommodates two parachute flares/sonobuoys. A drogue tray must be installed on each store prior to being inserted into the launching tube. A nose fairing is used to reduce drag and protect the breech cap electrical assembly cables. Four breech caps are located on the front of the dispenser. A safety switch safes the



Characteristics

Length (Inches)	36.0
Diameter (Inches)	4.9
Weight (Pounds)	30.0
Suspension	dispensers

Figure 3-11. LUU-2A/B, -B/B Aircraft Parachute Flare



Characteristics

Length (Inches)	110.0
Diameter (Inches)	14.0
Weight (Pounds)	
Empty	128.0
Loaded	352.0 - 368.0

Figure 3-12. SUU-44/A Dispenser

electrical circuitry of the dispenser. Pivotable shear latches with shear-pins secure each loaded launching tube until ejection takes place.

The first release pulse initiates the impulse cartridge of number one launching tube. Gas from the fired cartridge fills the expansion chamber in front of the forward store exerting force against both stores causing the shear-pin of the aft shear-latch assembly to shear releasing the latch and allowing both stores to be ejected. The airstream strips the drogue tray from the stores initiating the flare delay ignition sequence or rotochute deployment. The SUU-44/A ejects both stores in the tube at the same time. After each cartridge is fired, the dispenser stepping switch steps to the ready position for firing the cartridge of the next tube.

WARNING

Remain clear of aft end of the dispenser when cartridges are installed. Ejection forces are capable of propelling a store to a distance of 50 feet.

Refer to the External Stores Limitations Table for carriage and dispensing restrictions.

3.12.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), Tactical Manual Pocket Guide, for current preflight checks.

3.13 SUU-25 F/A DISPENSER

3.13.1 Description. The SUU-25 F/A dispenser (Figure 3-13) is a reusable four-tube launcher capable of carrying and ejecting rearward eight LUU-2 B/B aircraft parachute flares. The ability of the dispenser to launch one flare at a time doubles its operational capability in comparison to the SUU-44/A dispenser.

Each of the four launching tubes accommodates two parachute flares. A flare adapter kit must be installed on each flare prior to being inserted into the launching tube. A nose cone is used to reduce drag and protect the breech cap electrical assembly cables. Eight breech and four loading/unloading caps are located on the front of the dispenser. A SAFE/ARM stepper switch and a safety switch controls and safes the electrical circuitry of the dispenser. Pivotable retaining links with shear-pins secure each flare in the launching tube until ejection takes place.

The first release pulse steps the stepper switch from ARM to position 1 initiating the first impulse cartridge. Gas from the fired cartridge is routed to the expansion area in front of the rear flare of the number one launching tubes and exerts force against the flare causing the shear-pin of the aft retaining link to shear releasing the link and allowing the flare to be ejected. The launcher tube arming hook assembly strips the flares adapter kit arming cap which retains the flare-timer knob which initiates the flare delay ignition sequence. The next release impulse steps the stepper switch to the next position and fires the impulse cartridge of the forward flare of the launching tube that was previously fired. Sequence of the ejection events are identical to the first flare release. The third release pulse steps the stepper switch to the rear flare of the next launching tube.

WARNING

Remain clear of aft end of dispenser when cartridges are installed. Ejection forces are capable of propelling a flare to a distance of 50 feet.

Refer to the External Stores Limitations Table for carriage and dispensing restrictions.

Characteristics

Length (Inches)	107.0
Diameter (Inches)	14.0
Weight (Pounds)	
Empty	260.0
Loaded	
Flares	490.0

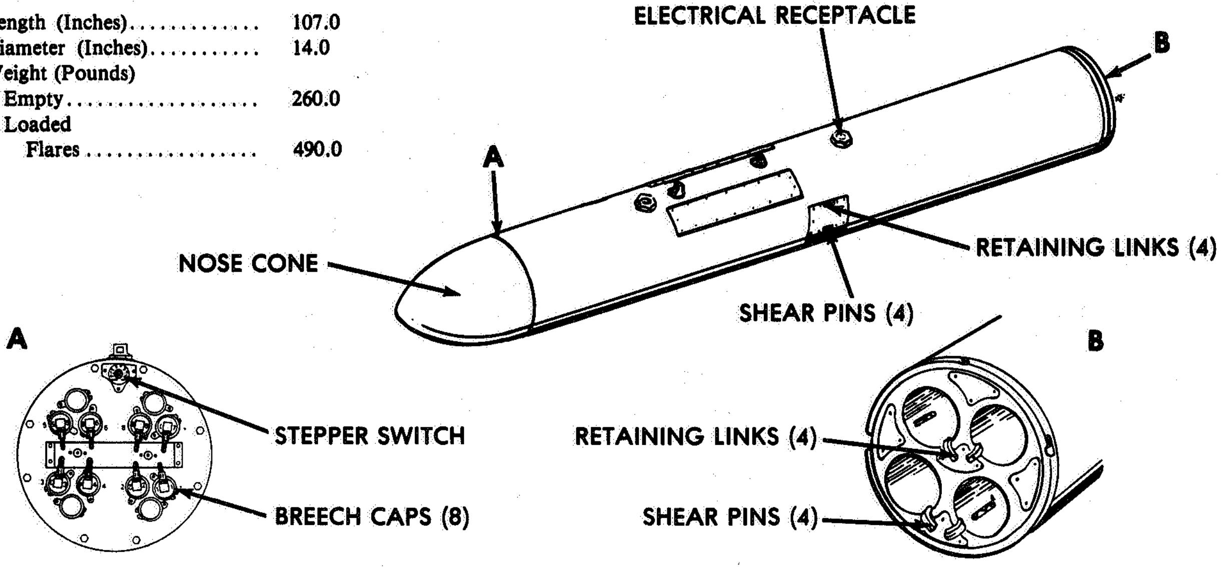


Figure 3-13. SUU-25 F/A Dispenser

3.13.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), Tactical Manual Pocket Guide, for current preflight checks.

3.14 ROCKETS

3.14.1 Introduction. The 2.75-inch and 5.00-inch aircraft rockets, with the selection of warheads available, provide an effective attack capability against a variety of targets. JMEMs provide the applicable data for selecting the rocket/warhead/fuze to best satisfy operational requirements.

An aircraft rocket system consists of a multitube jettisonable launcher loaded with assembled rockets mated to the aircraft station and armament circuitry.

Conventional aircraft rockets have an unguided boost phase and a ballistic flight phase. The motor provides a high impulse over a short period of time and consists of a high strength tube closed at the forward end, a propellant grain, an igniter assembly, and a fin and nozzle assembly. Folding or wrap-around fins allow multiple rockets (4 to 19), dependent on launcher used, to be carried on each authorized station. The launcher tube locking detent prevents forward motion of the rocket unitl a predetermined force level of the initiated motor is achieved. Departure of the first rocket removes the forward launcher frangible fairing if installed.

3.14.2 Rocket Warheads. The following is a summary of the operational characteristics of warheads used on 2.75-inch and 5.00-inch rockets. For a more detailed description, refer to NAVAIR 11-85-5.

Rocket warheads are classified according to tactical requirements and functioning as follows:

1. HE-FRAG (High Explosive Fragmentation)

2. HEAT (High Explosive Antitank)

3. AT/APERS (High Explosive Antitank/Antipersonnel)

4. GP (High Explosive General Purpose)

5. SMOKE

   (a) WP — white phosphorous

   (b) PWP — plasticized white phosphorous

6. FLARE

7. PRACTICE (Inert).

3.14.2.1 Rocket Warheads (2.75-Inch). The following paragraphs describe the characteristics of warheads used on 2.75-inch rockets. Refer to Figure 3-14 for warhead fuze combinations.

3.14.2.1.1 Mk 1 (HE-FRAG). This warhead is used against personnel and soft targets such as parked aircraft, personnel carriers, radar emplacements, trucks, small craft, and so forth. The warhead contains approximately 1.4 pounds of HBX-1 or Composition B-4 explosive. Construction is of soft steel and total weight is approximately 6.5 pounds.

3.14.2.1.2 M151 (HE-FRAG). Tactical application of the warhead is the same as the Mk 1. The warhead contains approximately 2.3 pounds of Composition B-4 explosive. Construction is of soft steel or cast iron, and total weight is approximately 9.4 pounds.

3.14.2.1.3 M229 (HE-FRAG). This warhead is an elongated version of the M151 warhead. It has the same tactical application and is designed *ONLY* for use with slow-speed aircraft and the Mk-40 rocket motor. The warhead contains approximately 4.8 pounds of Composition B-4 explosive. Total weight is approximately 16.9 pounds.

3.14.2.1.4 Mk 5 (HEAT). This warhead is used against armored targets such as tanks, bunkers, armored vehicles, and so forth. The warhead contains a shaped charge which produces a high-energy jet that penetrates armor. It contains approximately 0.9 pound of Composition B explosive. Construction is of steel, and total weight is approximately 6.6 pounds.

3.14.2.1.5 Mk 67 (SMOKE). This warhead is used to provide smoke for target marking. The warhead casing is constructed of aluminum alloy rather than steel. An explosive burster charge of Composition B disperses the 2.6 pounds of white phosphorous (WP). Total weight is approximately 5.2 pounds.

3.14.2.1.6 M156 (SMOKE). This warhead is identical in function to the Mk 67 but uses a soft steel casing. An explosive burster charge of composition B-4 disperses the 2.0 pounds of white phosphorous (WP). Total weight is approximately 9.7 pounds.

3.14.2.1.7 M257 (FLARE). The M257 flare warhead is used to provide delivery aircraft with a standoff capability for battlefield illumination. This enables the delivery aircraft to attack the target area using the illumination the flare provides. The permanently installed base fuze (M442) functions at motor burnout (1.5 seconds after launch) which provides a 9.0-second delay prior to drogue chute deployment and subsequent main chute deployment and flare ignition. Total elapsed time from motor ignition to flare illumination is approximately 13.5 seconds. The warhead produces 1,000,000 candlepower for a minimum of 100 seconds and illuminates approximately 1 square mile of area. Average descent of the deployed flare is 13 feet/second. The warhead is launched to attain an altitude of 2,000 to 4,000 feet at a range of 3,000 meters prior to functioning when using the Mk-40 motor and a range of 3,472 meters with the Mk-66 Mod 2 motor. Total weight of the warhead is 10.7 pounds.

TYPE	WARHEAD	FUZE
HE-FRAG	Mk 1	Mk 352/FMU-90/B M427/M423
	M151/M229	Mk 352/FMU-90/B M427/M423 M429
HEAT	Mk 5	Mk 181
SMOKE	Mk 67	Mk 352 M427/M423
	M156	Mk 352 M427/M423
FLARE	M257	M442
PRACTICE	Mk 1 (Inert)	Mk 178 (Inert)
	Mk 5 (Inert)	Mk 181 (Inert)
	Mk 61	--
	M151 (Inert)	M435 (Inert)
	M229 (Inert)	M435 (Inert)
	M230	M435 (Inert)
	WTU-1/B	--
	WTU-14/B	--

NOTE:
1. MK 1/M229/MK 5 WARHEAD AND FMU-90/B IMPACT OR M429 PROXIMTY FUZES ARE NOT AUTHORIZED WITH MK 66 MOTOR.
2. M423 IMPACT FUZE ONLY AUTHORIZED WITH MK 40/66 MOTOR.
3. M229 WARHEAD AND M429 PROXIMTY FUZE ONLY AUTHORIZED WITH MK 40 MOTOR.
4. M257 WARHEAD ONLY AUTHORIZED WITH MK 40/66 MOTOR.

Figure 3-14. 2.75-Inch FFAR Warhead/Fuze Combinations

3.14.2.2 Practice Warheads (2.75-Inch). Practice warheads (Figure 3-15) are either dummy configurations or inert-loaded service warheads in which the weight and placement of an inert filler gives the practice warhead and the explosive-loaded service warhead the same ballistic characteristics and MUST BE DELIVERED within the same parameters as service warheads.

WARNING

> In some cases, the same Mk and Mod numbers have been assigned to both service and practice warheads. Personnel should verify that warhead markings are correct and that practice and service warheads are *not* interchanged.

Practice	Service
Mk 1, Mk 61, WTU-14/B	Mk 1
Mk 5	Mk 5
M151, M230, WTU-1/B	M151
M229	M229

Figure 3-15. Practice Warheads Used to Simulate Service Warheads

3.14.2.3 Rocket Warheads (5.00-Inch). The following paragraphs describe the characteristics of warheads used on 5.00-inch rockets. Refer to Figure 3-16 for warhead/fuze combinations.

3.14.2.3.1 Mk 24 (GP). This high-explosive, general-purpose warhead can be used against a variety of targets including concrete buildings or bunkers, surface vessels, and so forth. Tactical use is dependent on fuzing configuration. The Mod 0 has a permanently installed base fuze. Mods 1/2 do not have a base fuze. It contains approximately 9.5 pounds of Composition B explosive. Total weight is approximately 45.0 pounds.

3.14.2.3.2 Mk 32 (AT/APERS). This warhead is effective against heavy or light armored targets. Against heavily armored targets, a point detonating fuze is used to initiate the shaped charge. For light targets, a proximity fuze is used. It contains approximately 15.0 pounds of Composition B explosive. Total weight is approximately 43.5 pounds.

3.14.2.3.3 Mk 33 (Flare). This warhead is designed for illuminating surface areas at a distance ahead of the delivery aircraft so that the launching aircraft may avail itself of the parachute-suspended flare in attacking the target. The permanently installed mechanical time fuze functions approximately 15 seconds after launch and initiates the expulsion and ignition of the flare from the warhead casing. Flare burn time is approximately 90 seconds. Total weight is approximately 46.0 pounds.

3.14.2.3.4 Mk 34 (SMOKE). This warhead is designed for target marking or incendiary use when a Mk-93 proximity fuze is installed. It contains approximately 19.3 pounds of plasticized white phosphorous (PWP). Total weight is approximately 51.0 pounds.

3.14.2.3.5 Mk 63 (HE-FRAG). This warhead is designed to produce large quantities of fragments in an effective airburst pattern. The warhead is proximity fuzed to take advantage of the designed uniform fragment distribution. Some Mods also contain zirconium cubes or rings to give the warhead an incendiary effect in addition to its fragmentation capability. It contains approximately 15.0 pounds of Composition B explosive. Total weight is approximately 56.5 pounds.

TYPE	WARHEAD	FUZE	NOTES
HE-FRAG	Mk 63	Mk 93	(1)
		Mk 352/FMU-90/B	(3)
GP	Mk 24	Mk 93/M414A1	(1)
		Mk 188	(2)
		Mk 352/FMU-90/B	(3)
		Mk 191	(4)
AT/APERS	Mk 32	Mk 93/M414A1	(1)
		Mk 188	(2)
		Mk 352/FMU-90/B	(3)
SMOKE	Mk 34	Mk 93	(1) (5)
		Mk 188	(2)
		Mk 352	(3)
FLARE	Mk 33	Mk 193	(6)
PRACTICE	Mk 6	Nose plug	
	Mk 24	Nose plug/steel ogive	
	Mk 32	Nose plug	
	WTU-11/B	Mk 93 INERT	

NOTES:
(1) Proximity Fuzes (VT)
(2) Point Detonating Impact (PD)
(3) PD Fuze which requires BBU-15/B adapter booster for installation
(4) Only Mod 0 has Mk 191 base fuze permanently installed
(5) Requires special adapter for installation
(6) Permanently installed

Figure 3-16. 5.00-Inch Zuni Warhead/Fuze Combinations

3.14.2.4 Practice Warheads (5.00-Inch). Practice warheads (Figure 3-17) are either dummy configurations or inert-loaded service warheads in which the weight and placement of an inert filler give the practice warhead and the explosive-loaded service warhead the same ballistic characteristics and MUST BE DELIVERED within the same parameters as service warheads.

WARNING

> In some cases, the same Mk and Mod numbers have been assigned to both service and practice warheads. Personnel should verify that warhead markings are correct and that practice and service warheads are *not* interchanged.

3.14.3 Rocket Motors. All airborne rocket motors (Figures 3-18 and 3-19) include the following components: an igniter, propellant grain with a stabilizing rod, nozzle, fin assembly, and firing contact disc/band. The motor is ignited by 28-vdc aircraft power distributed by the launcher intervalometer to each tube firing contact. Gas pressure resulting from the burning igniter charge ruptures the igniter case and ignites the propellant grain. Propellant gases rupture the nozzle seal/seals and exerts forward pressure (motor movement) which overcomes the launcher tube locking detent. The salt-coated stabilizing rod, located in the center of the propellant grain, prevents unstable burning of the grain and reduces flash and afterburning which contribute to compressor stalls and flame out of jet engines. The folding fins (FFAR) on the Mk-4/-40 2.75-inch motors are forced open by propellant gases as the motor exits the launcher tube. The wrap-around (WAFFAR) fins on the Mk-66 2.75-inch and Mk-71 5.00-inch motors are spring actuated to open and seat in the nozzle body fin slots as the motor exits the launcher tube.

Practice	Service
Mk 6 Mod 7, Mk 24	Mk 24
Mk 32	Mk 32
WTU-11/B	Mk 63

Figure 3-17. Practice Warheads Used to Simulate Service Warheads

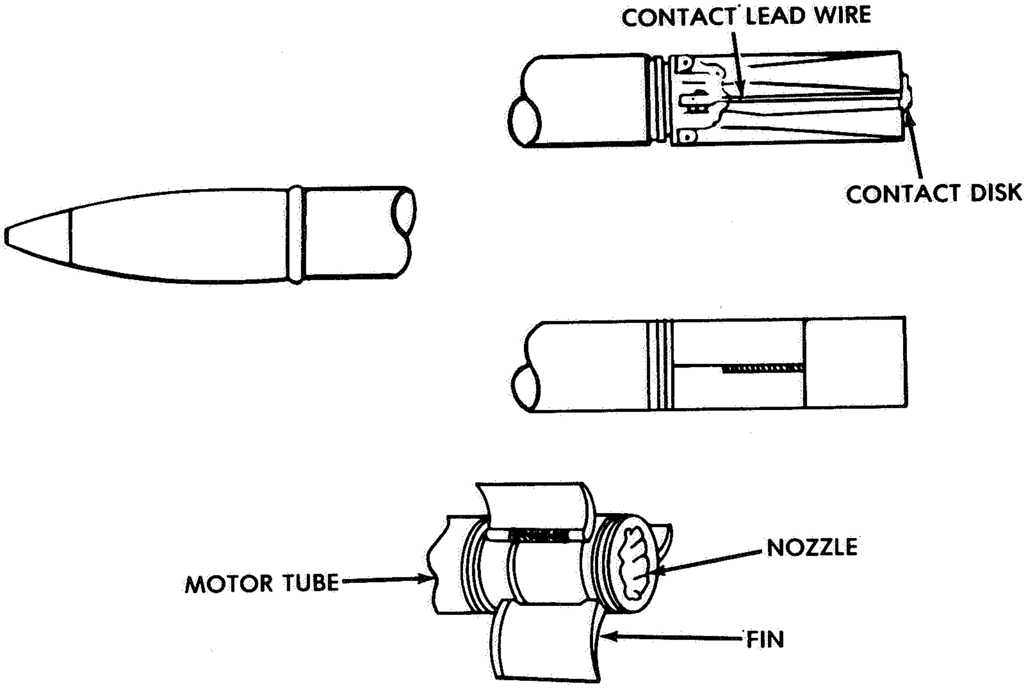
3.14.3.1 Mk-4 Rocket Motor (2.75-Inch). The Mk-4 rocket motor produces an average thrust of 720 pounds and is used with all configurations of the 2.75-inch FFAR for fixed-wing aircraft and *should not* be used for extremely low-speed launch velocities. Approximate motor weight is 11.4 pounds.

3.14.3.2 Mk-40 Rocket Motor (2.75-Inch). The Mk-40 rocket motor is identical to the Mk 4 with the exception of the nozzles. They are scarfed to provide rotational spin and stabilization when fired at low initial launch velocities. The Mk 40 was specifically designed for helicopters and slow-speed aircraft. Approximate motor weight is 11.4 pounds.

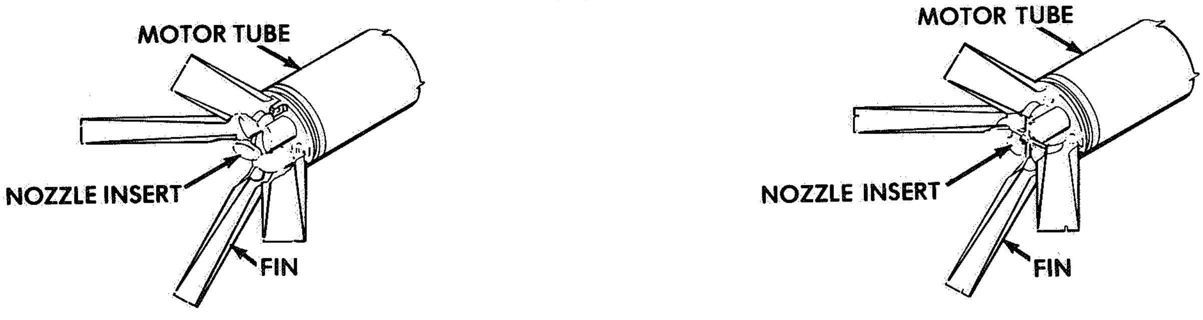
3.14.3.3 Mk-66 Mod 2 WAFFAR Rocket Motor (2.75-Inch). The Mk-66 Mod 2 WAFFAR motor is designed to replace the Mk-4/-40 FFAR motors and can be carried and launched from both fixed-/rotary-wing aircraft. The motor is considered HERO safe and does not require the use of an RF barrier on the aft end of the rocket launcher. The Mk-66 Mod 2 *can only be used* in LAU-61 C/A and LAU-68 D/A rocket launchers. The three spring-loaded, wrap-around fins in conjunction with the fluted exhaust nozzle provide controlled spin and stabilized flight. The motor produces an average thrust of 1,360 pounds for

Characteristics

Warhead (Mk 4/40 MTR)	**MK 1/5**	**M151**	**M229**	**MK 67**	**M156**	**M257**
Weight (Pounds).........	18.0........	20.8........	28.3........	16.6........	21.0.....	22.2
Warhead (Mk 66 MTR)		**M151**		**MK 67**	**M156**	**M257**
Weight (Pounds).........		22.8........		18.6........	23.1.....	24.2



MK 66 MOD 2

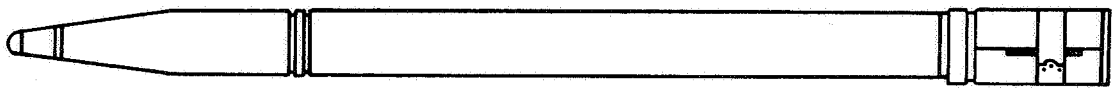


SCARFED NOZZLE **STANDARD NOZZLE**

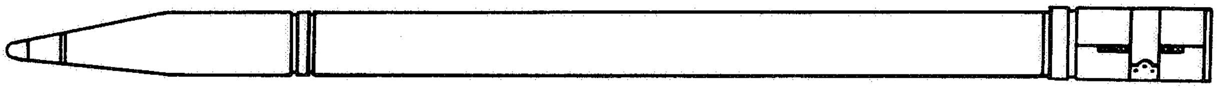
Figure 3-18. 2.75-Inch FFAR Rocket Motor Mk-4/-40 Mods

Characteristics

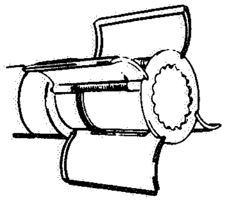
Warhead	**MK 24**	**MK 32**	**MK 33**	**MK 34**	**MK 63**
MK 71 Mod 0 Weight (Pounds)	111.9	110.3	NA	117.8	123.4
MK 71 Mod 1 Weight (Pounds)	124.5	122.9	125.4	130.4	136.0



MK 71 MOD 0 MOTOR



MK 71 MOD 1 MOTOR



MK 71 MOD 0 & 1

Figure 3-19. 5.00-Inch Zuni Motors Mk-71 Mods 0/1 a duration of 1.08 seconds. Approximate motor weight is 13.4 pounds.

3.14.3.4 Mk-71 Mod 0 Rocket Motor (5.00-Inch). The Mk-71 Mod 0 motor produces an average thrust of 7,780 pounds. These motors have the same propellant grain and motor tube as the obsolete Mk-16 motor. The Mk-71 Mod 0 motor has spring-loaded folding wrap-around fins which provide controlled spin and improves the ballistic dispersion of the rocket. Approximate motor weight is 66.85 pounds.

3.14.3.5 Mk-71 Mod 1 Rocket Motor (5.00-Inch). The Mk-71 Mod 1 differs from the Mod 0 by having a different propellant grain and is 6 inches longer. It produces an average thrust of 8,100 pounds. The fin and nozzle assembly incorporates spring-loaded, wrap-around fins which provide controlled spin and improves the ballistic dispersion of the rocket. Approximate motor weight is 79.5 pounds.

3.14.4 Rocket Launchers. The rocket launchers currently in service are described in the following paragraphs.

3.14.4.1 LAU-61-Series Rocket Launcher. The LAU-61 (Figure 3-20) is an all-metal reusable launcher with a capacity for 19 2.75-inch rockets. The LAU-61 A/A, -61 B/A can be loaded with Mk-4/-40 rocket motors and the LAU-61 C/A with Mk-4/-40/-66 motors. The launcher has a preflight selectable fire-mode selector switch (RIPPLE/SINGLE) located on the aft bulkhead. When RIPPLE is selected, one aircraft firing pulse fires all rockets with a 40-millisecond interval between departing rockets. The SINGLE position allows only one rocket to be fired for each aircraft firing pulse. The 21-position rotary stepper-switch intervalometer, located on the aft bulkhead, is an electromechanical unit which distributes a firing pulse to each launcher tube motor contact. Each launcher tube has a motor detent retainer which retains the rocket motor until ignition. A frangible nose fairing can be installed to reduce aerodynamic drag and will depart the launcher when the first rocket is fired. The aft fairing is aluminum and is designed to remain intact and direct debris away from the aircraft. The LAU-61 B/A and LAU-61 C/A have a thermal protective coating on the exterior surface and *require* the use of thermal barriers for all shipboard operations. The aft thermal barrier also provides RF protection for the Mk-4/-40 rocket motor. Ground safety is provided by a safe-arm device (switch with safety pin) which opens the circuit from the launcher receptacle and grounds the intervalometer.

WARNING

(U) *Mixing* of rocket motors is *prohibited.*

3.14.4.2 LAU-68-Series Rocket Launcher. The LAU-68 (Figure 3-21) is an all-metal reusable launcher with a capability for seven 2.75-inch rockets. The LAU-68 B/A can be loaded with Mk-4/-40 rocket motors and LAU-68 D/A with Mk 4/-40/-66 motors. The launcher has a preflight selectable fire-mode selector switch (RIPPLE/SINGLE) located on the aft bulkhead. When RIPPLE is selected, one aircraft firing pulse fires all rockets with a 60-millisecond interval (LAU-68 B/A) or 40-millisecond interval (LAU-68 D/A) between departing rockets. The SINGLE position allows only one rocket to be fired for each aircraft firing pulse. The nine-position rotary stepper-switch intervalometer, located on the aft bulkhead, is a electromechanical unit which distributes a firing pulse to each launcher tube motor contact. Each launcher tube has a motor detent retainer which retains the rocket motor until ignition. A frangible nose fairing can be installed to reduce aerodynamic drag and will depart the launcher when the first rocket is fired. The aft fairing is aluminum and is designed to remain intact and direct debris away from the aircraft. The LAU-68 D/A has a thermal protective coating on the exterior surface and

Characteristics

Weight (Pounds)	
(Empty)	128.0 (A/A) - 145 (B/A) -148 (C/A)
(Loaded w/fairings)	458.4 - 748.56
Length (Inches)	83.0
Diameter (Inches)	15.7
Suspension (Inches)	14.0

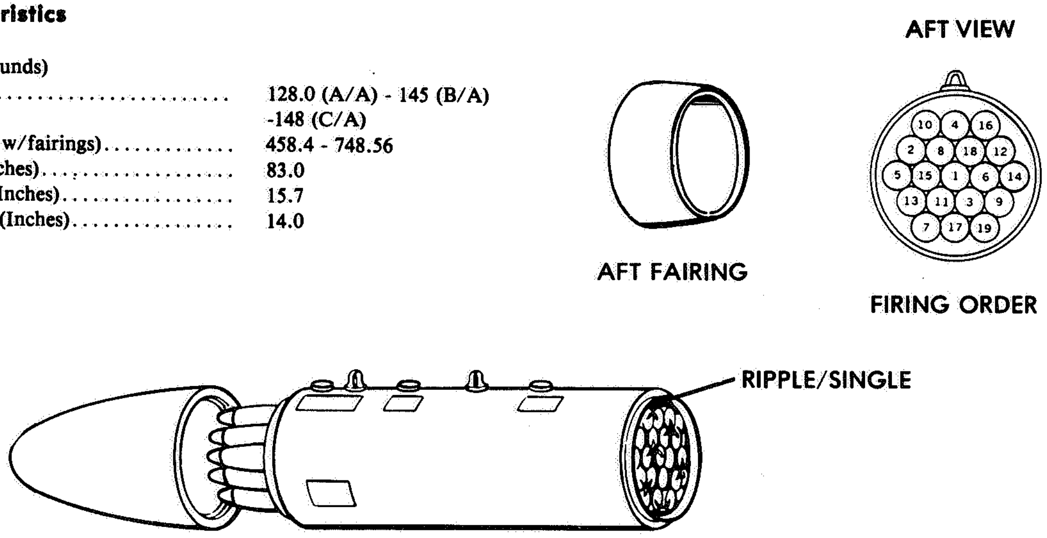


Figure 3-20. Rocket Launchers (2.75-Inch FFAR LAU-61 Series)

Characteristics

Weight (Pounds)	
(Empty)	65.0 (B/A) - 78.0 (D/A)
(Loaded w/fairings)	186.1 - 298.68
Length (Inches)	71.0
Diameter (Inches)	10.0
Suspension (Inches)	14.0

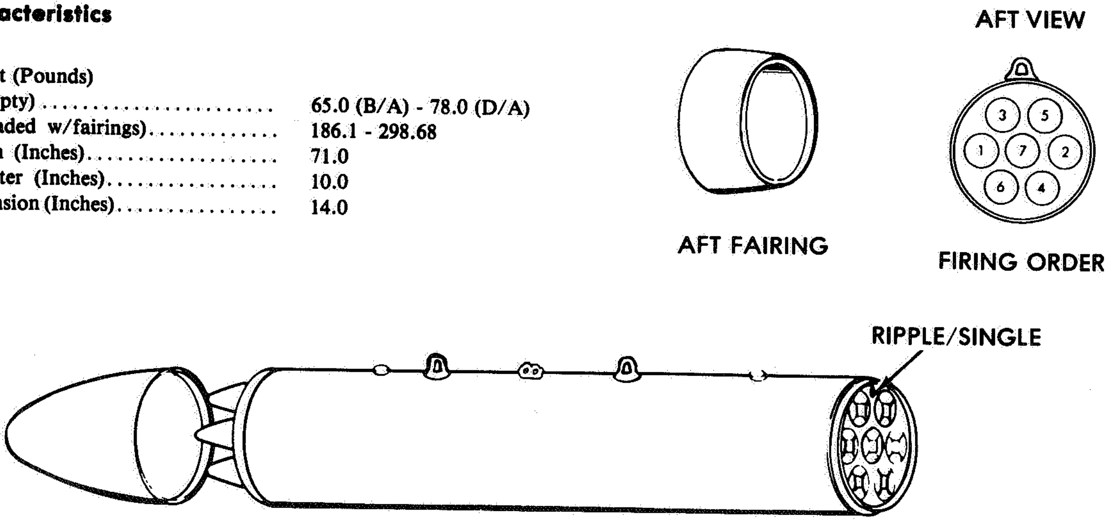


Figure 3-21. Rocket Launchers (2.75-Inch FFAR LAU-68 Series)

requires the use of thermal barriers for all shipboard operations. The aft thermal barrier also provides RF protection for the Mk-4/-40 rocket motor. Ground safety is provided by a safe-arm device (switch with safety pin) which opens the circuit from the launcher receptacle and grounds the intervalometer.

WARNING

(U) *Mixing* of rocket motors is *prohibited.*

3.14.4.3 LAU-10-Series Rocket Launcher. The LAU-10 (Figure 3-22) is an all-metal reusable rocket launcher with a capacity for four 5.00-inch rockets. The launcher has a preflight selectable fire-mode selector switch (RIPPLE/SINGLE) located on the aft bulkhead. When RIPPLE is selected, one aircraft firing pulse fires all rockets with a 95-millisecond interval between departing rockets. The firing pulse must exceed a 0.5-second duration to ensure a complete fire out when RIPPLE is selected. The SINGLE position allows only one rocket to be fired for each aircraft firing pulse. The internal non-selectable rotary stepper-switch intervalometer is a electromechanical unit which distributes a firing pulse to each launcher tube motor contact. Each launcher tube has a motor detent which retains the rocket motor until ignition. Frangible fairings can be installed to reduce aerodynamic drag and will depart the launcher when the first rocket is fired. A thermal coated forward fairing is required for all shipboard operations when Mk-32 warheads are used. The LAU-10 D/A has a thermal protective coating on the exterior surface and *requires* the installation of a thermal shield over the aft end of the launcher for all shipboard operations. The thermal shield and fairing provide increased cook-off time in the event of a fire. Ground safety is provided by a safe-arm device (switch with safety pin) which opens the circuit from the launcher receptacle and grounds the intervalometer.

3.14.5 Limitations. Refer to External Stores Limitations Table, Appendix A, for carriage and firing/jettison restrictions.

3.14.6 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)) Tactical Manual, Pocket Guide, for current preflight checks.

3.15 ROCKET FUZING

3.15.1 General. Rocket fuzes are divided into three categories based on mode of functioning:

1. Impact
2. Time
3. Proximity.

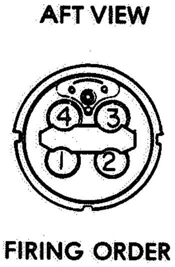
Impact firing fuzes are referred to as point detonating (PD) or base detonating (BD) according to their location in the warhead. The Mk-191 fuze, which is permanently installed in the Mk-24 Mod 0 (GP) warhead, is the only current base detonating fuze in use.

Time fuzes detonate/initiate the warhead at a preset time after rocket launch and motor burnout. The three time fuzes currently in use are the Mk 193, M442, and FMU-136/B, which are installed in the Mk-33 Mod 1, M257, and Mk-84 Mod 4 warheads.

Proximity fuzes radiate an RF frequency at right angles to the warhead axis and upon receipt of a reflected RF energy (target reflection), detonate the warhead. The insensitivity of the fuze allows ripple firing (salvo) of the rockets and precludes using the fuze for air-to-air missions. Water content of the target increases the magnitude of the target reflected signal which results in a higher burst height (warhead detonation). The fuze senses foliage and will detonate the warhead above the foliage with the burst height dependent on growth density and its moisture content.

Characteristics

Weight (Pounds)	
(Empty)	107.0 (C/A) - 136.0 (D/A)
(Loaded w/fairings)	554.9 - 696.4
Length (Inches)	128.9
Diameter (Inches)	13.9
Suspension (Inches)	14.0 and 30.0



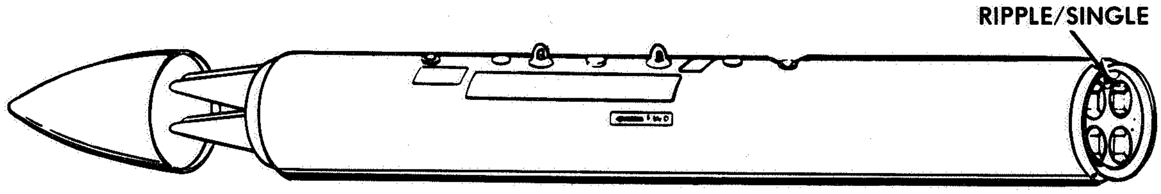


Figure 3-22. Rocket Launcher (5.00-Inch LAU-10 Series)

3.15.2 Arming. Two types of arming mechanisms are used. One mechanism uses a combination of rocket motor acceleration/time for arming. This mechanism provides a safe-separation distance between the delivery aircraft and rocket warhead by delaying the completion of the arming cycle for a specific period of time if the rocket motor maintains a minimum acceleration level. Approximately 20g's to 30g's of sustained acceleration for about 1 second is required for arming. Variation of arming distances should be anticipated due to manufacturing tolerance and temperature effects on the fuze mechanism. The second type of mechanism employs acceleration/time integration to enable with actual arming occurring at motor burnout. Distance is determined by an acceleration time integration mechanism in the fuze, and time is determined by motor burnout/clock mechanism.

3.15.3 Safety. Rocket fuzes contain internal safety/arming devices to prevent arming for any condition other than the completion of a clean rocket launch. Delivery (launching) of airborne rockets within the appropriate release envelopes given for this aircraft should preclude possible damage to the aircraft.

Note

As some fuzes have shorter arming distances/times, *only* those motor/warhead fuze combinations listed in the warhead/fuze combination charts in the rocket descriptions are authorized for carriage/release.

3.15.4 Rocket Fuzes. The following paragraphs provide a brief description of all currently authorized rocket fuzes (Figure 3-23). Refer to NAVAIR 11-1F-2 for detailed functioning information.

3.15.4.1 Mk-181 Impact (PD). The Mk-181 nose fuze was designed to be used only with the Mk-5 2.75-inch HEAT warhead. It will function against mild steel plate of 0.125-inch minimum thickness at impact angles between 0° to 60° perpendicular to the plate. The fuze has instantaneous impact functioning and requires a sustained acceleration of 20g's in order to arm. Air travel to arm in approximately 330 to 660 feet.

3.15.4.2 Mk-352 Impact (PD). The Mk-352 nose fuze was designed to be used in either 2.75-inch/5.00-inch rocket warheads. It requires an adapter booster BBU-15/B for installation in 5.00-inch warheads. The fuze is sensitive to low-angle impacts on all targets including water and will function when it impacts 0.016-inch thick aluminum sheet at approach angles as small as 3° to 5°. The fuze has instantaneous impact functioning and requires a sustained acceleration of 20g's minimum in order to arm. Air travel to arm is approximately 800 to 1,200 feet and time to arm is 1.07 to 1.36 seconds at 40g's.

3.15.4.3 FMU-90/B Impact (PD). The FMU-90/B nose fuze is identical in all respects to the Mk-352 fuze with the exception of a 0.05-second impact functioning delay time. It can also be used in most configurations as the Mk 352.

WARNING

Because of the short arming time, M423 nose fuzes *must not be used* in rockets fired from high-speed aircraft.

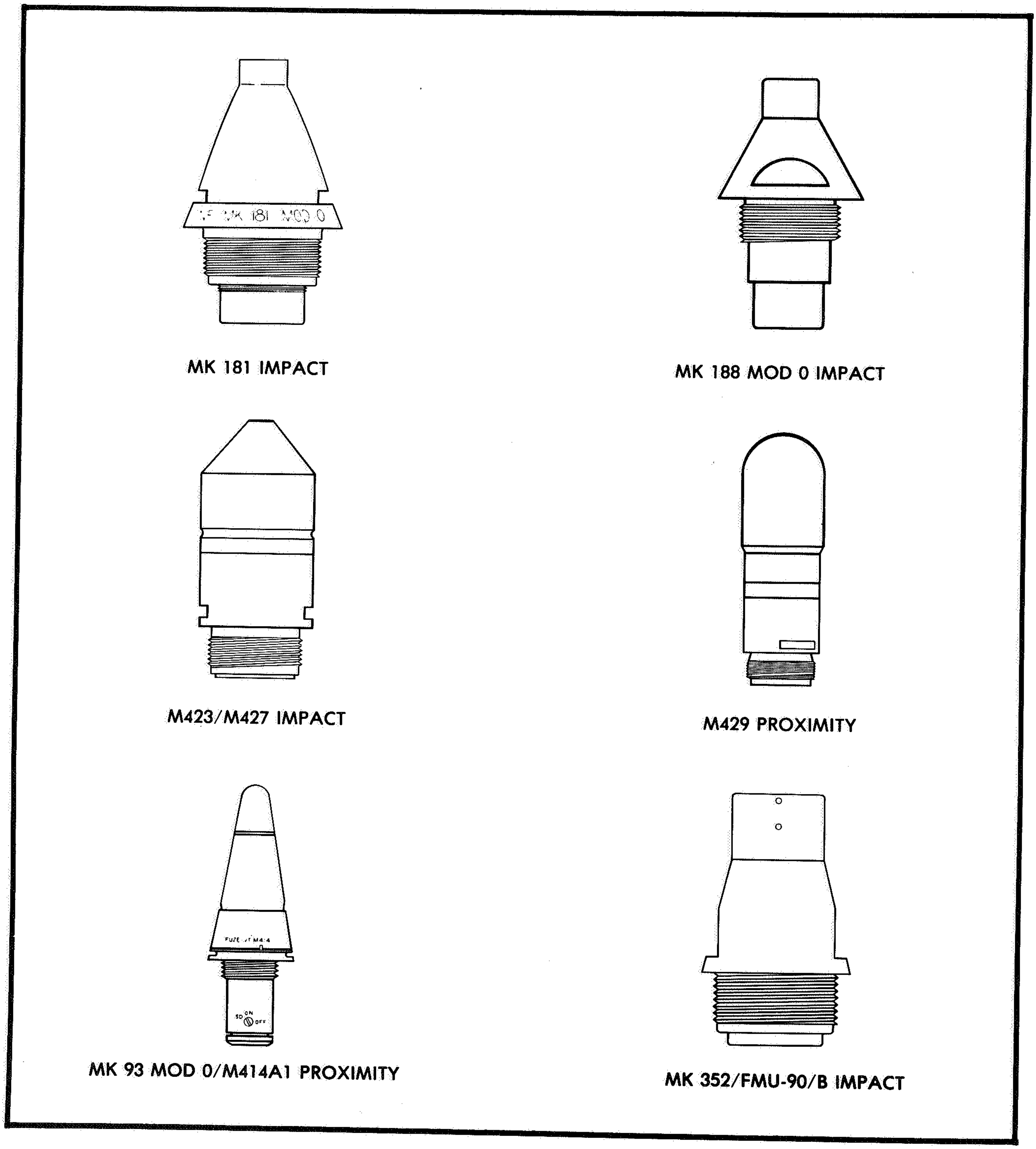
3.15.4.4 M423 Impact (PD). The M423 nose fuze is used *only* with Mk-40/-66 2.75-inch rocket motors on slow-speed aircraft/helicopters. The fuze is sensitive to low-angle impacts as low as 5° and will function on water targets. The fuze has instantaneous impact functioning and requires a sustained acceleration of 20g's in order to arm. Air travel to arm is approximately 140 to 300 feet and time to arm is 0.63 to 0.82 seconds at 27g's.

3.15.4.5 M427 Impact (PD). The M427 nose fuze is identical to the M423 fuze with the exception of a longer arming distance of 800 to 1,250 feet which requires a time to arm of 1.09 to 1.34 seconds at 40g's. It was designed for use with high-speed aircraft; however, it may be used on slow-speed aircraft by using a greater target standoff distance.

3.15.4.6 Mk-188 Mod 0 Impact (PD). The Mk-188 Mod 0 nose fuze was designed to be used with 5.00-inch warheads against ground/water targets. The fuze will function reliably at low-angle impacts. The fuze has instantaneous impact functioning and requires a sustained acceleration of 20g's in order to arm. Air travel to arm is approximately 400 to 800 feet and time to arm is 0.7 and 0.9 seconds.

3.15.4.7 Mk-191 Impact (BD). The Mk-191 base fuze is permanently installed in the 5.00-inch Mk-24 Mod 0 GP warhead. The fuze has a .002- to .007-second functioning delay after impact and does not function reliably on impact with water. The fuze was designed for hard target penetration and must be used in combination with a hardened steel nose plug installed in the nose fuze cavity when used for that purpose. This fuze requires a sustained acceleration of 30g's in order to arm. Air travel to arm is approximately 400 to 800 feet and time to arm is approximately 0.8 to 1.0 second at 50g's.

3.15.4.8 Mk-193 Time. The Mk-193 time fuze is permanently installed in the 5.00-inch Mk-33 Mod 1 flare warhead. The fuze provides a preset fixed time interval which commences



MK 181 IMPACT

MK 188 MOD 0 IMPACT

M423/M427 IMPACT

M429 PROXIMITY

MK 93 MOD 0/M414A1 PROXIMITY

MK 352/FMU-90/B IMPACT

Figure 3-23. Airborne Rocket Fuzes

at launch. The flare candle will be ignited 13 to 17 seconds after launch. This fuze requires a sustained acceleration of 30g's in order to enable and arms at motor burn out. Air travel to arm is approximately 1,000 feet and time to arm is approximately 1.0 second.

3.15.4.9 M442 Time. The M442 time fuze is permanently installed in the M257 2.75-inch flare warhead. The fuze provides a preset fixed time interval which commences at rocket launch. The flare candle will ignite approximately 13.5 seconds after launch. The fuze requires a sustained acceleration of 16g's in order to enable and arms at motor burnout. Air travel to arm is approximately 1,800 feet (Mk-40 motor) or 2,137 feet (Mk-66 motor) and time to arm is approximately 1.0 second.

3.15.4.10 M429 Proximity. The M429 proximity nose fuze was designed to be used *only* with the 2.75-inch M229 HE-FRAG warhead/Mk-40 rocket motor combination on slow-speed aircraft/helicopter operating against ground targets at low approach angles. The fuze has two modes of operation: airburst (primary) and impact (secondary) backup in the event of proximity failure. Target approach angles between 5° to 15° will provide a burst height between 2 to 12 feet (7-feet nominal over average ground). The fuze requires a sustained acceleration of 30g's in order to arm. Air travel to arm is approximately 500 to 1,100 feet and time to arm is 1.04 to 1.34 seconds at 27g's.

3.15.4.11 Mk-93 Mod 0/M414A1 Proximity. The Mk-93 Mod 0/M414A1 nose fuzes were designed to be used with 5.00-inch warheads against ground targets at low approach angles. This fuze coupled with the Mk-32 AT/APERS warhead is highly effective for flak suppression and antipersonnel missions. The fuze has two modes of operation: airburst (primary) and impact (secondary) backup in the event of proximity failure. The only difference between the two fuzes is the burst-height range. The Mk-93 Mod 0 fuze provides a higher burst height of 15 to 40 feet. Burst-height ranges for both fuzes are based on average ground and at target approach angles of 20° to 40°. This fuze requires a sustained acceleration of 30g's in order to enable and arms at motor burnout. Air travel to arm is approximately 1,000 feet and time to arm is approximately 1.0 second.

3.15.4.12 BBU-15/B Adapter Booster. The BBU-15/B adapter booster was designed to allow the installation of the Mk-352/FMU-90/B 2.75-inch impact nose fuzes in Mk-24/-32/-34/-63 5.00-inch warheads.

3.15.5 Preflight Checks. There are no preflight checks to be performed on rocket fuzes.

3.16 GPU-2/A GUN POD

3.16.1 Description. The GPU-2/A gun pod (Figure 3-24) is a self-contained gun system consisting of an M197, three-barrel, 20-mm gun coupled to a single-ended linkless ammunition system, and an ammunition storage drum with a capacity of 300 rounds of M50-series ammunition. The gun pod is equipped with an electrical control system and power supply consisting of a nickel-cadmium battery and charger that drives and sequences the gun system.

The gun pod is designed to mount on suspension racks having 14- or 30-inch hook spacing. The forward suspension lug provides adjustments for boresighting the pod on the aircraft, in both azimuth and elevation within a ± 2° cone. Any additional boresighting in elevation can be obtained by threading the lugs in or out as needed prior to loading the gun pod.

The gun is electrically operated and fired by the internal battery located in the aft section of the pod with the associated charger which automatically recharges the battery in flight whenever the gun pod is selected. The battery has a heater circuit and sensor that functions to maintain the battery at the optimum operating temperature.

Characteristics

Length (Inches)	127.6
Diameter (Inches)	19.0
Weight (Pounds)	
Empty	417.0
Loaded	586.0
Suspension (Inches)	14.0/30.0
Capacity (Rounds)	300 - M50 series
Rate of Fire (RPM)	750/1500
Maximum Effective Range (Feet)	2000.0

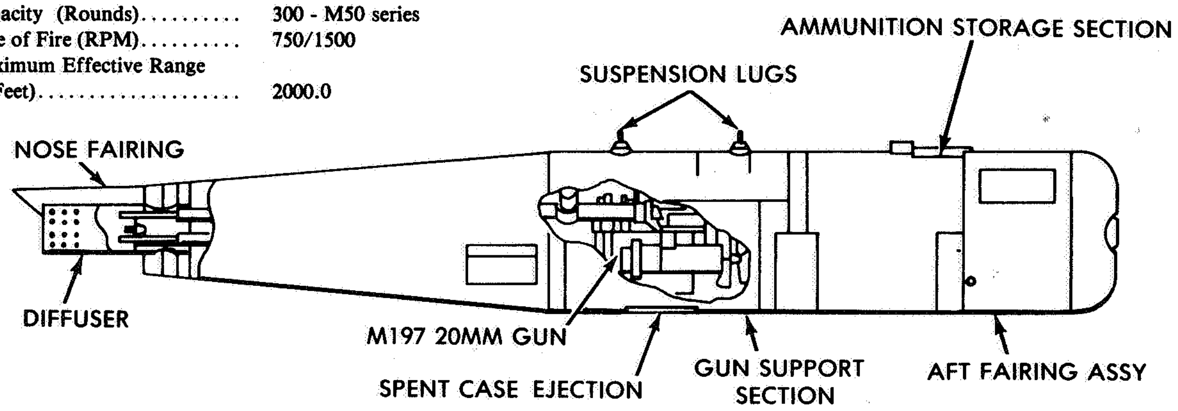


Figure 3-24. GPU-2/A Gun Pod

The M197 gun provides a 750 or 1,500 rounds per minute (RPM) rate of fire (low/high). Spent cases are ejected from the gun and out the bottom of the pod. Release of the WING ARM FIRE switch automatically clears the gun.

Ground safety is provided by the Fire Volts access door located on the starboard side of the gun support section of the pod. The firing circuitry between the battery and gun is interrupted when the door is in the OPEN position.

3.16.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)) Tactical Manual Pocket Guide, for current preflight checks.

3.17 20-mm AMMUNITION

3.17.1 Description. A 20-mm round consists of a steel cartridge case, an electric primer, propellant powder, and the projectile. The primer is ignited by 28-volt dc electrical power from the aircraft armament system. The primer ignites the propellant power which forms a gas as it burns. This gas pressure forces the projectile through the gun barrel. Three types of ammunition are discussed, the only significant difference being the projectile (Figure 3-25).

The 20-mm ball projectile (TP) is a hollow steel body that does not contain a filler. This projectile is used for target practice.

The 20-mm, high-explosive incendiary (HEI) projectile is composed of an incendiary

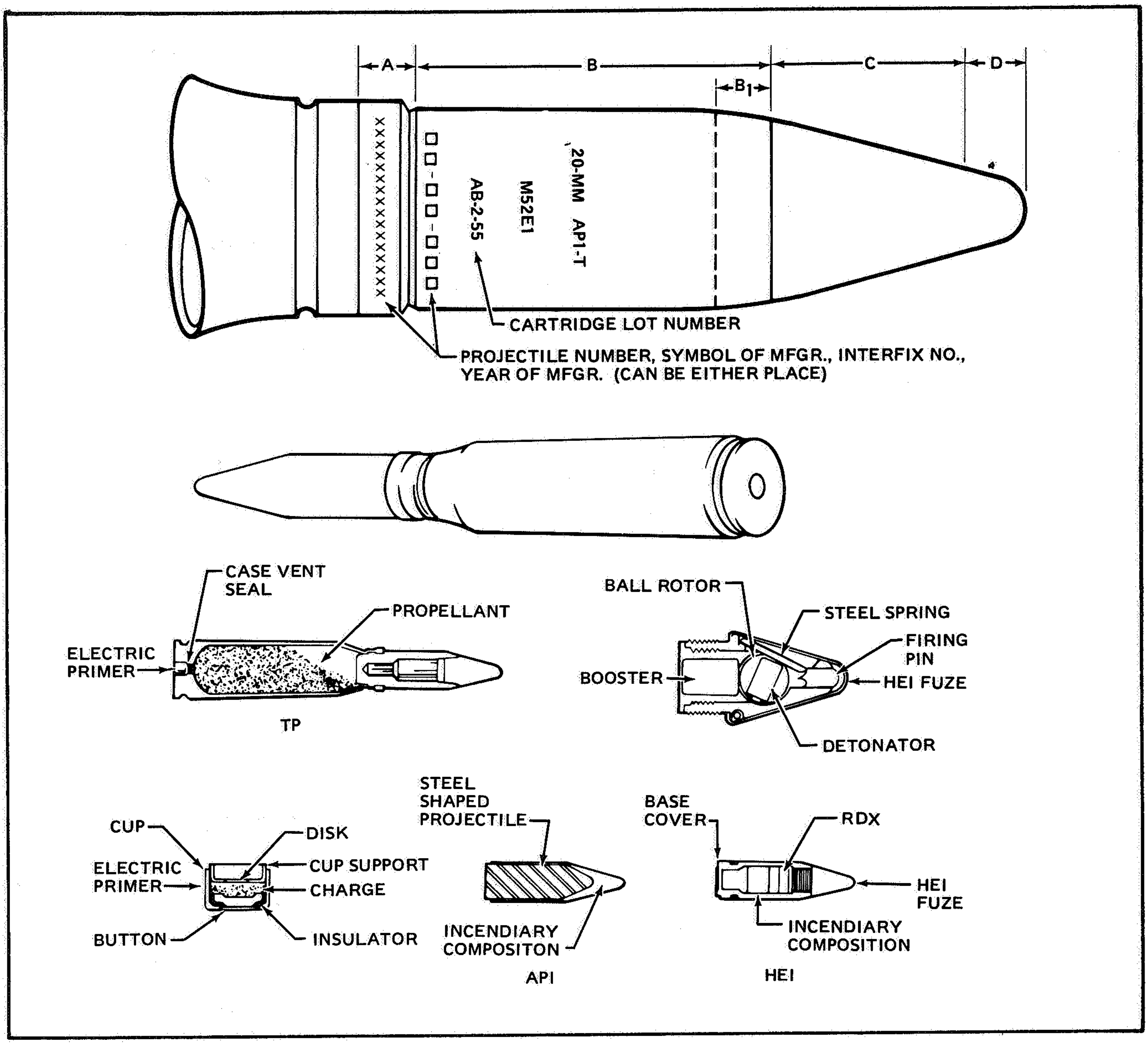


Figure 3-25. 20-mm Ammunition (Sheet 1 of 2)

compound, explosive compound, and a fuze. This type projectile is used against aircraft and light material targets.

The 20-mm armor piercing tracer (APT) projectile is similar to the API except that a cavity is machined in the back of the projectile body to receive a tracer mixture. Instead of a false ogive and loaded nosepiece, a hollow windshield is used to bring the stubby projectile body up to a standard length and contour.

PROJECTILE TYPE (Except as Noted)	COLOR OF PAINTING				COLOR OF MARKING
	LOCATIONS				
	A	B	C	D	
Dummy M51A1B1	No Paint (Copper)	Chromate Finish	Chromate Finish	Chromate Finish	Black
Armor Piercing Incendiary Tracer (API-T) M52E1	No Paint (Copper)	Black Red Band In B_1 Area	No Paint	No Paint	Orange T's (Below B_1 Area)
High Pressure Test (HPT) M54A1	No Paint (Copper)	Purple	Purple	Purple	Black
Target Practice (TP) M55A2	No Paint (Copper)	Blue	Blue	Blue	White
High Explosive Incendiary (HEI) M56A3/M56E5	No Paint (Copper)	Yellow Red Band In B_1 Area	No Paint (Chromate)	No Paint (Chromate)	Black
Target Practice Tracker (TP-T) M221 (M220 Cartridge)	No Paint (Copper)	Blue	Blue	Blue	Orange T's (Location B_1)
High Explosive Incendiary Tracer (HEI-T) M242	No Paint (Copper)	Yellow Red Band In B_1 Area	No Paint (Chromate)	No Paint (Chromate)	Red T's (Below B_1)
Plastic Dummy Cartridge M254	No Paint (White Plastic)	No Paint (White Plastic)	No Paint (White Plastic)	No Paint (White Plastic)	Black

WEIGHT/ROUND – 0.6 POUND
MUZZLE VELOCITY – 3380 ± 50 FT/SEC

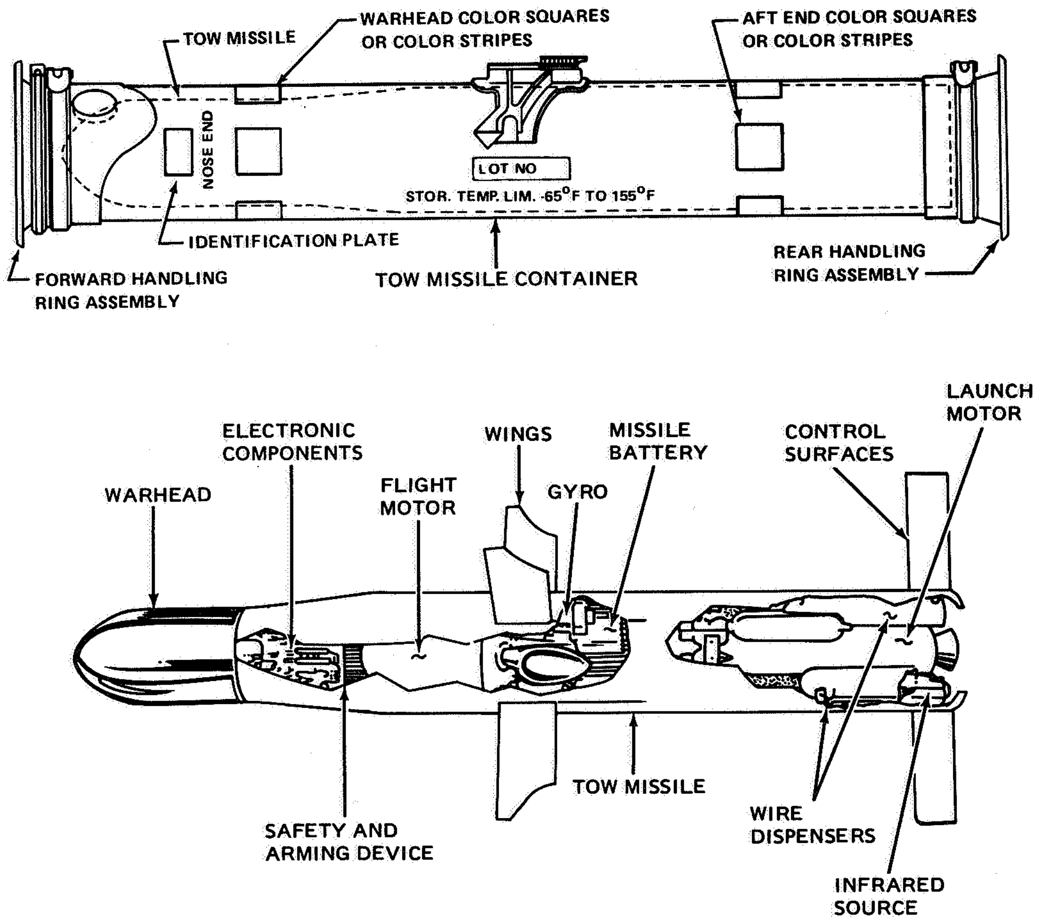
Figure 3-25. 20-mm Ammunition (Sheet 2 of 2)

The 20-mm Mk-149 Mod 0 armor piercing discarding SABOT (APDS) ammunition is composed of a Mk-68 Mod 0 projectile which consists of a depleted uranium subcaliber penetrator, an aluminum pusher plug, and a glass-filled, nylon-discarding SABOT that breaks into four segments upon leaving the muzzle. The primary use of this ammunition is against hard material targets such as light armored vehicles. Restrictions for use of this ammunition are identified as note 8 of Figure A-4.

3.18 TOW MISSILE BGM-71A and BTM-71A

3.18.1 Description. The TOW missile is a solid propellant guided missile. It is tube launched, optically tracked, and wire command-linked guided. The missile is similar to a conventional round of ammunition with respect to handling, storage, and loading characterisitcs. Although the missile consists of six major sections (launch container, warhead, electronic section, flight motor section, center section, and aft section), it is issued and handled as a complete round of ammunition. The only difference between the TOW missile BTM-71A and the BGM-71A is that the former does not contain explosive in the warhead section. (Figure 3-26.)

3.18.2 Tabulated Data. Refer to Figure 3-27 for tabulated data on both the tactical and practice missiles.



PHYSICAL CHARACTERISTICS
TOW MISSILE BGM-71A

Length	50.558 in.
Diameter	8.625 in.
Volume	1.71 cu. ft.
Weight	54.16 lbs.
Explosive weight	
Warhead	5.2 lbs.
Launch motor	1.2 lbs.
Flight motor	5.6 lbs.

Figure 3-26. TOW Missile BGM-71A

Tow Missile Tabulated Data

	Guided Missile, Surface Attack, BGM-71A	Guided Missile, Practice (Inert Warhead Live Motor) BTM-71A
Length	50.558 in	50.558 in
Diameter	8.625 in	8.625 in
Volume	1.71 cu ft	1.71 cu ft
Weight	54.16 lbs	54.16 lbs
Explosive weight*		
Warhead	5.2 lbs	None
Launch motor	1.2 lbs	1.2 lbs
Flight motor	5.6 lbs	5.6 lbs

*For Q-D purposes use only the sum of the explosive weights in the warhead and the flight motor.

Figure 3-27. TOW Missile Tabulated Data

3.18.3 Launch Container. The launch container is a cylindrical housing constructed of rugged fiber glass, laminated with epoxy resin. An electrical connector with associated wiring harness is built into the launch container to provide electrical connections between the missile and the launcher. The launch container provides protection for the missile during the handling operations. It also acts as an extension of the launch tube when the missile is loaded in the launcher.

3.18.4 Warhead Section. The warhead section consists of the warhead assembly, an ogive assembly, and a safety and arming device. The ogive forms the front of the warhead section. The warhead assembly forms the central portion. The safety and arming device is attached to the rear of the warhead assembly and fits into the center of the electronics section assembly. The warhead assembly is a shaped-charge device consisting of a welded outer case and mounting ring assembly, a liner cone, a compression pad, a phenolic bushing, a high explosive, and a booster charge. The ogive assembly serves two functions. One function is to serve as an aerodynamic cover for the forward end of the missile during flight. The other function is to detonate the fuze in the safety and arming device upon contact with the target. The safety and arming device allows safe handling, transportation, storage, and operation of the high-explosive warhead up to the point in missile flight where the round is designated to arm.

3.18.5 Electronics Section. The electronics section assembly contains all of the electronic circuitry used in the missile. The electronics section assembly receives missile steering signals from the attitude control gyro. The signals from the gyro are shaped and superimposed on the missile steering signals to produce missile stabilization. The electronics section also applies driving voltages to the four control-surface actuators.

3.18.6 Flight Motor Section. The flight motor propels the missile towards the target. The flight motor case consists of two parts and when joined serves as part of the missile skin. The electronic section is formed to the groove around the outside of the forward portion of the flight motor case. The aft flight motor case is joined to the forward flight motor case by a screw joint and has the four missile wings attached which provides stability for the missile in flight.

3.18.7 Center Section. The center section assembly consists of the center section case, the attitude control gyro, the three missile batteries, and the center section wiring harness. The forward end of the center section case is formed to the groove around the outside of the aft case of the missile flight motor. The two flight motor exhaust nozzles terminate at two ports in the center section case.

3.18.8 Aft Section. The missile aft section assembly is composed of the aft section case, two wire dispensers, a light (infrared) source, and an actuator system. The wire dispensers are mounted in the extreme aft end of the aft section assembly. Each wire dispenser is a small-diameter aluminum bobbin mounted parallel to the missile longitudinal axis. The missile actuator system occupies most of the missile aft section assembly. The actuator system consists of the actuator subsystem and the control surface assembly. The control surface assembly consists of the four control surfaces, their extending springs, and the bulkhead to which they are mounted. The light source is mounted at the extreme aft end of the missile so that infrared energy is emitted toward the launcher when the missile is in flight. This infrared energy is detected by the infrared sensor in the TOW optical sight to determine the missile's position in space.

3.18.9 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVIAR 01-110HC-1T(B)), Tactical Manual Pocket Guide, for current preflight checks.

3.19 100-GALLON AUXILIARY FUEL TANK

3.19.1 Description. The 100-gallon auxiliary fuel tank (Figure 3-28) is an external, jettisonable, aerodynamic fuel tank is carried to supplement the aircraft internal fuel supply. It can be configured for 14-inch suspension only. Fuel/air adapters and the electrical connector is located forward of the forward suspension lug to provide the appropriate mating of aircraft and tank.

Air pressure from the pump assembly located on the aircraft rack pylon forces the fuel from the tank into the internal fuel system. A fuel probe incorporated within the tank transmits fuel quantity information to the cockpit.

3.19.2 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), Tactical Manual Pocket Guide, for current preflight checks.

3.20 AIM-9 SIDEWINDER SUSPENSION EQUIPMENT

3.20.1 ADU-299-Series Missile Launcher Adapter. The ADU-299 adapter (Figure 3-29) provides a mechanical and electrical interface for any aircraft that requires the LAU-7/A guided missile launcher to be suspended from a bomb rack. The adapter has 14- or 30-inch suspension lugs which are locked into the bomb rack hooks. Two electrical receptacles (forward and aft) are provided, one of which will provide the connection point for the aircraft pylon connector. The LAU-7/A launcher is bolted and electrically connected to the adapter prior to attaching the adapter to the bomb rack. The ADU-299 is available in two versions, A/A and /E, of which the /E can *only* be used on aircraft without sidewinder expanded acquisition mode (SEAM).

3.20.2 LAU-7/A-Series Guided Missile Launcher. The LAU-7/A launcher (Figure 3-30) provides carriage and release of all AIM-9 Sidewinder missiles. The launcher is comprised of several assemblies that provide missile in-flight retention and security, electrical interface between the aircraft and missile, and nitrogen cooling to the missile IR detector.

The cylindrical nitrogen receiver (bottle) located in the aft section of the launcher will provide approximately 2 hours of continuous cooling to the missile IR detector after the cockpit missile cooling switch has been actuated. The internal power supply provides the connection point for the missile umbilical cable and amplifies the missile detector target tone to 1500 Hz for the pilot's headset. Missile control fin retainers, located on both sides of the forward section of the launcher, provide temporary security to prevent in-flight flutter. The forward retainer spring is used for the AIM-9 L/M fins and the aft retainer spring is used for the AIM-9H fins. Ground safety is accomplished by a Detent Wrench Safety Pin which mechanically prevents the missile from leaving the launcher if accidently fired. Refer to NAVAIR 11-75A-54 for additional details.

3.21 TACTICAL AIR CREW COMBAT TRAINING SYSTEM POD (TACTS/AIS)

3.21.1 Description. The TACTS/AIS pod (Figure 3-31) is a subsystem of the advanced Tactical Air Crew Combat Training system developed to improve aircrew proficiency by transmitting altitude, velocity, acceleration, angular rate data, weapon status data, aerological sensor data, and responses to interrogation to a range ground station. This information is correlated and displayed in real time as it occurs and is recorded for postmission debriefing.

The total system (air and ground subsystems) supports aircrew training in missile envelope recognition (AIM-7 Sparrow/AIM-9 Sidewinder) and allows recorded observation of the results of simulated missile firings against aircraft under realistic but controlled engagement conditions. It also enables aircrews to observe the results of operations (anti radiation missiles) against ground target threats (SAMs).

The TACTS/AIS pod is physically similar to the AIM-9 Sidewinder and is compatible with all aircraft with LAU-7/A3 launcher capability. Operation of the pod is accomplished by utilizing the ac and dc aircraft power through the launcher umbilical hookup connector.

Refer to the External Stores Limitations Table, Appendix A, for authorized versions of the TACTS/AIS pod that are cleared for carriage.

3.21.2 Training Modes. The TACTS/AIS pod has five modes of operation which enable aircrew training to be accomplished in a logical sequence of progression in acquisition of combat skills. One or all five modes can be used during a given exercise depending on the programming of the ground station. Modes 1 and 2 are based on the aircraft being within rule-of-thumb

Characteristics

Length (Inches)	114.0
Diameter (Inches)	18.28
Weight (Pounds)	
Empty	51.0
Full	765.0
Suspension (Inches)	14.0

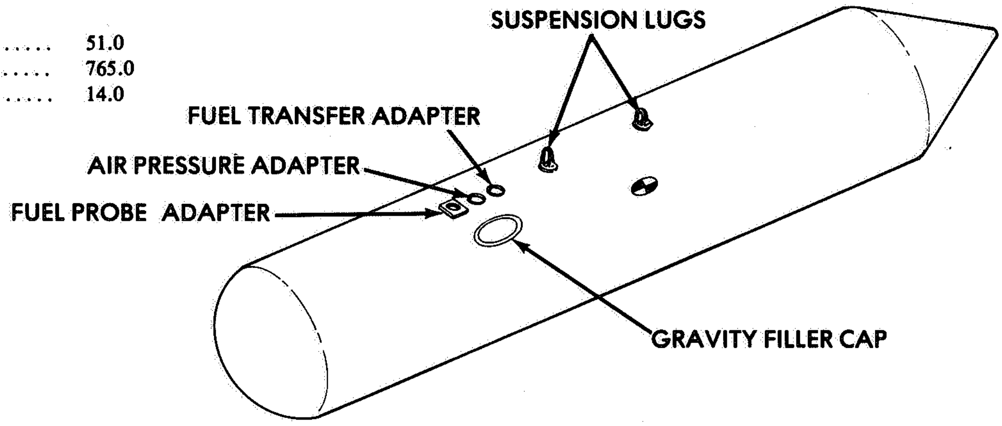


Figure 3-28. 100-Gallon Auxiliary Fuel Tank

Characteristics

Length (Inches)	48.6
Weight (Pounds)	24.0
Suspension (Inches)	14 or 30

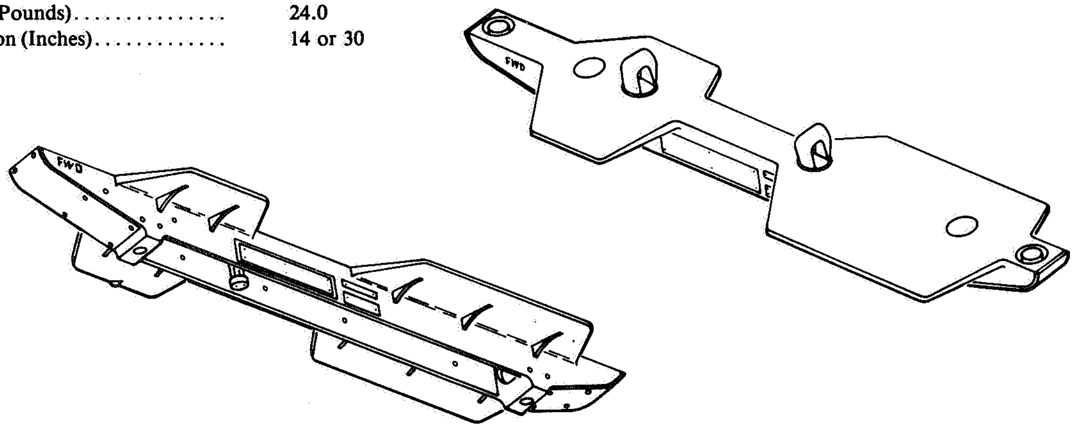
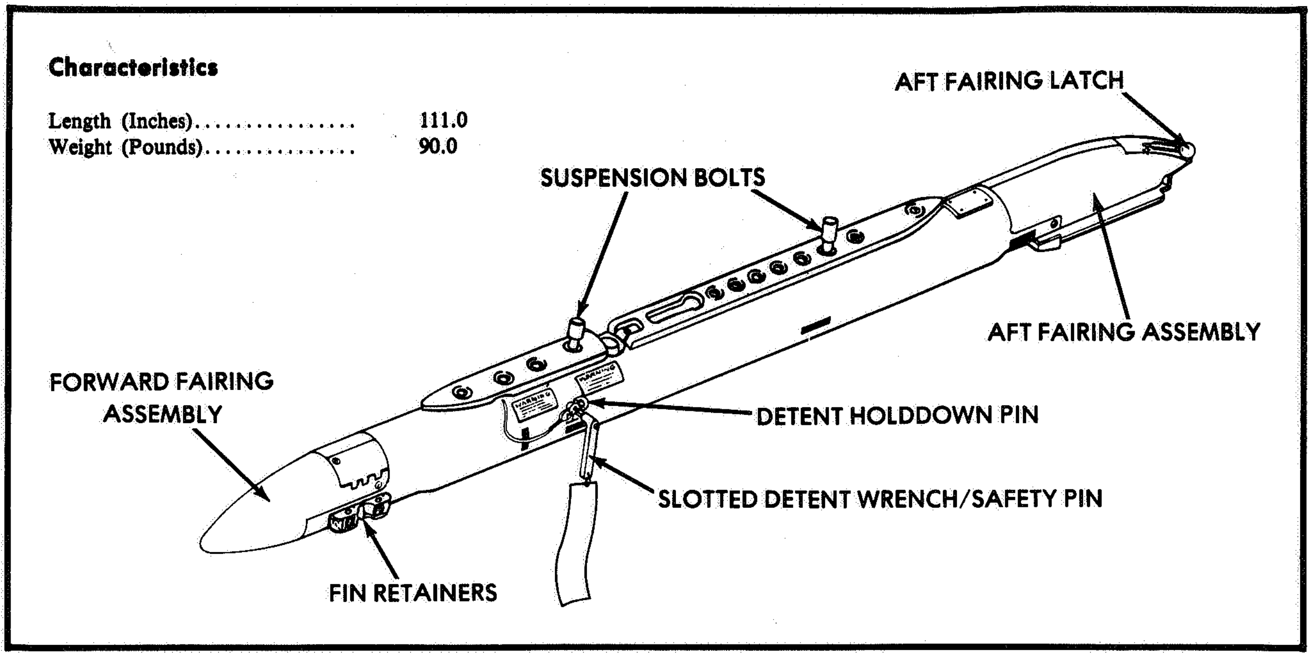


Figure 3-29. ADU-299-Series Missile Launcher Adapter

missile and firing boundaries/envelopes. Modes 3, 4, and 6 use real-time missile simulations for providing realistic instruction in ACM tactics and missile capabilities/P_k probabilities. Modes 1 and 3 are considered non-firing modes that provide a continuous tone when the aircraft is within the proper envelope. Modes 2, 4, and 6 are firing modes and require a trigger squeeze to initiate envelope calculations or missile simulations.

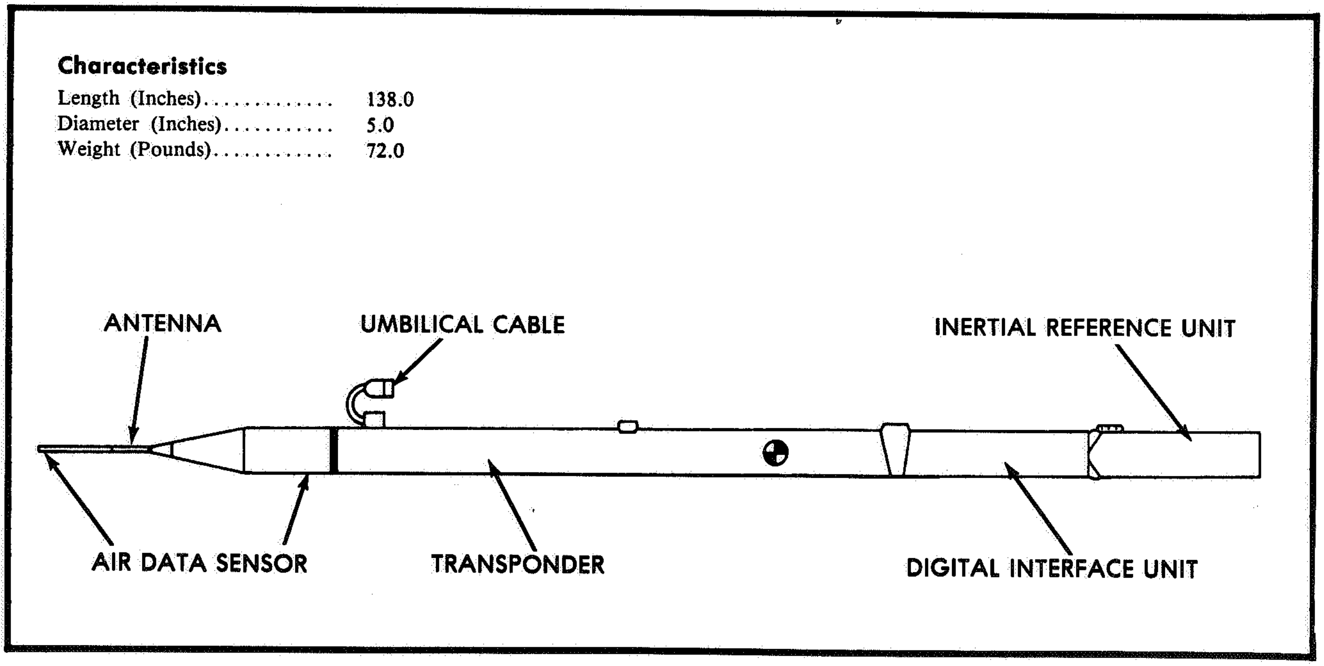
3.21.3 Preflight Checks. Refer to NWP 55-3-AH1 PG (NAVAIR 01-110HC-1T(B)), Tactical Manual Pocket Guide for current preflight checks.



Characteristics

Length (Inches)	111.0
Weight (Pounds)	90.0

Figure 3-30. LAU-7/A-Series Guided Missile Launcher



Characteristics

Length (Inches)	138.0
Diameter (Inches)	5.0
Weight (Pounds)	72.0

Figure 3-31. Tactical Aircrew Combat Training Systems (TACTS/AIS POD)

CHAPTER 4

Weapon System Employment

4.1 GENERAL

The attack helicopter possesses a high degree of maneuverability in other than overhead maneuvers. The capability to perform quick reversals and abrupt changes in attitude and airspeed permits the attack helicopter to employ guns, rockets and missiles in a defensive/retaliation role against attacking enemy aircraft. On occasion, operational considerations may dictate that attack helicopters be committed to a contested air environment. Attack helicopter flight crewmembers should have a basic knowledge of air combat maneuvering techniques. Operational tests and evaluations will continue to expand current tactics (CH. 12).

4.2 CREW CONCEPT

Simulation studies and operational flights have verified that it is advantageous for individual attack helicopter crewmembers to fly with the same pilot/gunner as much as possible in the air-to-air environment.

4.3 BASIC EMPLOYMENT CONSIDERATIONS

Enemy air-to-air missile attacks on helicopters are severely limited by the difficulty of the attacked in acquiring low-flying aircraft on radar, background clutter and the fact that the helicopters can maneuver to mask their infrared signatures with relative ease. The most probable attack by enemy aircraft on helicopters will be attempted by gun firing aircraft. This brings the attacking aircraft within the range of the attack helicopter's weapons. A thorough understanding of the employment techniques and ballistics characteristics of each of the available attack helicopter weapons is necessary for effective employment. The basic ordnance firing procedures utilized in the air-to-ground role apply to the air-to-air employment except that the latter requires the pilot to compute the necessary lead angle to compensate for target speed. Closure rates and opening velocities must be considered to avoid wasting valuable weapons.

4.4 HELICOPTER AIR-TO-AIR WEAPONS

The primary air-to-air weapon currently used is the AIM-9 series, IR homing missile. The 20-mm gun pod, if mounted, possesses an air-to-air capability. Rockets can also be used for this purpose. Both 2.75-inch and 5-inch ZUNI rockets were originally designed for air-to-air employment.

Weapons control panels and firing procedures for air-to-air delivery are the same as for air-to-ground delivery except for the addition of AFC-170 and AFC-171 for AIM-9 missiles. Test results and reported combat firings support employment of the TOW missile against slow moving aerial targets but limited employment against tactical jets.

4.5 WEAPONS SELECTION CONSIDERATIONS (VERSUS FIXED WING)

The selection of the type of weapon to be used against an aggressor aircraft in an air-to-air engagement must be carefully considered. Field of view (FOV) and weapon boresight is critical to prevent the accidental engagement of a friendly aircraft. Keen lookout doctrine, situational awareness, and crew coordination is mandatory for successful employment of any weapon in an air-to-air engagement.

4.6 WEAPONS SELECTION CONSIDERATIONS (VERSUS HELICOPTERS)

The major problems in engaging an opposing helicopter will be range estimation, target speed, and target predictability. The range of opposing aircraft is more difficult to determine unless the aircraft is in a hovering mode close to the ground that can be transposed to a map. If the helicopter is flying laterally at high speed, rockets and missiles are of limited effectiveness. The 20-mm gun increases the capability considerably. Because of the increased penetration, range, accuracy, and explosive properties of the cannon, it is an excellent air-to-air weapon. With the current 2.75-inch rocket system, the probability of a hit on a moving helicopter is very low. However, these rockets can be highly effective against helicopters in a landing zone or flying massed formations.

Aircraft flying in a very heavy configuration will be penalized in maneuverability and agility. In all probability, friendly aircraft will be unable to afford such a penalty and may have to consider jettisoning some ordnance. If the decision is made to jettison ordnance, drop that which is heaviest and least effective against aircraft. Keep the missiles and 20-mm guns that will be most effective.

4.7 TOW MISSILE AS AN ANTIAIR WEAPON

The use of the TOW missile system in an air-to-air engagement has some application, but is very limited. Against a tactical jet, employment of TOW would be extremely difficult under ideal conditions and virtually impossible under most battlefield conditions. Some of the major reasons for this include the following:

1. The difficulty in estimating optimum range for launching the missile against a target closing at approximately 800 FPS.

2. Experience has shown that, during engagements in which the attacker makes multiple runs, it is imperative that the copilot maintain visual contact with the attack as the pilot flies the aircraft. The fixed-wing attacker will most likely use hard climbing pull-offs and overhead maneuvers to position himself for subsequent runs, as this tactic gets him out of the firing envelope of the helicopter the quickest. In order to maintain visual contact during this maneuvering, the copilot will not be able to use the TSU. This complicates the problem by forcing the copilot to go from eye contact to low-power TSU and then to high-power during each attack. Throughout this sequence, the pilot will be maneuvering hard to avoid the attack while trying to get within launch constraints.

3. The TSU rate is 3° per second, which is the limiting factor against a closing target that begins to maneuver.

4. Should the attacker initiate a climb, the ability of the missile to close is highly questionable.

5. An aft shot at an aggressor during pull-off would be nearly impossible because of the difficulty involved in getting the AH-1T TOW turned around and within launch constraining, and then firing at a target that is opening at near supersonic speeds.

The use of TOW against an enemy helicopter is a very viable means of attack and, in some cases, would undoubtedly provide the best chance for a kill. It must be remembered, however, that many Soviet helicopters are more heavily armed than the AH-1. Should the enemy aircraft be the first to make visual acquisition, or should both aircraft acquire each other simultaneously, it is unlikely, though not impossible, that the AH-1T TOW will be able to get within launch constraints, fire, and track the missile down range while maneuvering against an attacker whose firepower exceeds his own. Should an enemy helicopter be acquired by an undetected AH-1T TOW, the TOW missile would undoubtedly be the best choice of a weapon to employ. This would be especially true if the enemy helicopter were hovering or moving slowly.

PART II

Aircraft Employment and Planning

Chapter 5 — Aircrew Planning and Coordination

Chapter 6 — Escort

Chapter 7 — Fire Support in a Sophisticated Threat Environment

Chapter 8 — Attack and Fire Support Patterns

Chapter 9 — Reconnaissance

Chapter 10 — Night and All-Weather Operations

Chapter 11 — Employment of Tow Missiles

CHAPTER 5

Aircrew Planning and Coordination

5.1 GENERAL

Attack helicopters support air, ground, and surface units by providing responsive fire support when and where it is required. During the planning phase, the attack helicopter commander determines the utilization of his assets to support the assigned mission. Based on final decisions of the commanders concerned, the attack helicopter flight executes its assigned portion of the scheme of maneuver. It should be noted that attack helicopters may be required to perform missions in an enemy high-threat, surface-to-air missile environment. In this regard, all tactics discussed herein should be modified to provide maximum survivability employing nap-of-the-Earth (NOE)/low-level flight techniques as appropriate.

5.2 PRINCIPLES OF EMPLOYMENT

5.2.1 Control. Control is the ability of a flight leader to position or maneuver the aircraft of his flight to accomplish the assigned mission. Control is enhanced by simplicity, effective communications, and the establishment of standard operating procedures.

5.2.2 Flexibility. Flexibility allows the flight leader to adapt to the combat situation. This flexibility is primarily a result of reliable communications, available firepower, and mobility.

5.2.3 Surprise. Surprise implies striking the enemy when, where, or in a manner that he is unable to counter effectively. The attack helicopter may achieve surprise by any or all of the following factors: time, place, direction, or aggressive tactics.

5.2.4 Firepower. Firepower is the amount of fire which may be delivered by a specific weapon system. The attack helicopter is capable of delivering a variety of weapons accurately on area targets.

Note

> In the planning and execution of air support missions, the attack helicopter normally will not be employed as the primary means of delivering close support. The fires of the attack helicopters should complement those of artillery, naval gunfire, and fixed-wing aircraft. However, if the situation, due to weather, response time, and type target, requires immediate reaction, the attack helicopter should be considered a primary means of close support.

5.2.5 Exploitation. Exploitation is taking full advantage of success in battle and following up initial gains. Every effort must be made to constantly exploit any enemy weakness. Because of its flexibility and firepower, the attack helicopter can provide ideal fire support for exploiting any known enemy weaknesses.

5.3 FIRE SUPPORT TERMINOLOGY

Operations may be classified by purpose as destruction, suppressive, or combined fires.

5.3.1 Destruction. All tactical air support missions whose primary purpose is to destroy enemy assets are considered to be destruction missions. The attack helicopter may be employed to destroy the enemy's ground forces in the immediate battle area by providing aerial fire support to the ground maneuver elements.

5.3.2 Suppressive. Suppressive missions are designed to render areas, weapons, or enemy forces ineffective. Typical missions conducted by the attack helicopter would be to furnish protection to a helicopterborne force along their approach and retirement lanes.

5.3.3 Combined. Since attack helicopters can carry more than one type of ammunition and armament, fires may be combined. For example, suppressive fires may be used to protect the transport helicopter while still engaged in destroying a point target.

5.4 IMMEDIATE SUPPORT

The common methods of immediate area target fire support are as follows.

5.4.1 Preparation. A change in the forecast tactical situation may require the firing of preparation fires into an area other than where originally planned. The rapid reaction capability of attack helicopters permits their recall from a lower priority mission to fire preparation for an assault.

5.4.2 Base of Fire. In the fluid, fast-moving situations found in conventional warfare, attack helicopters, without previous planning, may provide a base of fire for maneuvering elements.

5.4.3 Interdicting. As the tactical situation develops, immediate interdicting fires in support of the ground force may become necessary. To achieve good timing and target location and to locate friendly elements, interdicting fire delivery must be closely coordinated with the ground commander.

5.4.4 Targets of Opportunity. Targets of opportunity are those targets that randomly appear within the battle area and for which neutralization or destruction is desired. They must be engaged only when the engagement does not interfere with the primary tactical mission.

5.4.5 Suppressive. Area suppressive fires are those fires required for the defense of the aircraft against a hostile position within a determined quadrant. Generally, these will be high volume, short duration fires allowing contact to be broken.

5.5 PREPLANNED SUPPORT

Preplanned target fires, as with other supporting fires, are normally conducted to support a ground scheme of maneuver. Common preplanned air support methods are:

5.5.1 Preparation. Before and during the initiation of an assault, a heavy volume of preparation fire is delivered on a suspected or known enemy position. Various types of ammunition may be used in firing preparations.

5.5.2 Diversionary. Diversionary fires are delivered into an area to draw attention to it, with the intent that enemy forces may be drawn away from the principal area of operation. Diversionary fires may be used as an economy-of-force measure or in conjunction with ground offensive, defensive, or retrograde operations. The type ammunition used is determined by the situation.

5.5.3 Harassing. Harassing fires are those delivered into an area for the purpose of disturbing the rest, curtailing the movement, and lowering the morale of enemy troops by the threat of casualties or losses in material.

5.5.4 Interdicting. Interdicting fires are those delivered into a designated area to deny the unrestricted use of the area to the enemy or to prevent the unimpeded withdrawl of the enemy from the combat area. Interdicting fires may be on-call or fired at random to provide a harassing effect in support of offensive, defensive, or retrograde operations.

5.5.5 Counterpreparation. Counterpreparation fire may be preselected area fire for targets of opportunity. Counterpreparation is the delivery of fire into prepared enemy positions to deny the enemy a base of fire. Counterpreparation fires may be used against enemy mortar, artillery, armor, or other fire support weapons.

5.6 MISSIONS

It is important that proven attack helicopter tactics be taught and employed to the optimum. This will assure a common base from which new and improved concepts of attack helicopter employment can be derived.

5.6.1 Escort Missions. The attack helicopter will normally be employed to provide the necessary fire to accomplish a variety of escort missions to include:

1. Helicopterborne assault
2. Medical evacuations
3. Reconnaissance insertions and extractions
4. Resupply
5. Convoy cover land or water
6. Utility escort
7. Armed reconnaissance
8. Retrograde.

5.6.2 Additional Missions. In addition to the above escort missions, the armed helicopter can be utilized to perform the following additional missions:

1. Point defense against enemy armor
2. Visual reconnaissance
3. Aerial fire support
4. Tactical air coordinator (airborne)
5. Artillery and naval gunfire spotting.

5.7 GENERAL GUIDES FOR ATTACK HELICOPTER EMPLOYMENT

Factors affecting the employment of attack helicopters in addition to the mission, enemy, terrain, weather, and troops and equipment are the established (cardinal) rules. It is not always possible to follow the established rules precisely. These rules are guides which enhance mission success and increase survivability in the combat environment.

1. Know the situation. It is imperative that attack helicopter crews know the ground tactical situation if they are to provide the accurate, timely fire support required. Crewmembers must glean all the information possible from operations plans and orders and use thorough preflight briefing.

2. Brief to the man. To perform his duties properly, every crewmember of the flight must know the situation, the mission, and the plan of execution. Debrief the flight on completion of the mission. Debriefing will often bring out valuable intelligence information, and the crew will benefit from lessons learned.

3. Avoid flight in the high hazard zone. When possible, flight in the high hazard zone should be avoided. It will vary from area to area, under different intensities of conflict, and when facing different enemies. When required to operate in or pass through the high hazard zone, the flight should be completed as quickly as possible.

4. Avoid flying the 6 o'clock or tail-chase position. When both the section leader and the wingman fly the same ground track, the following unacceptable conditions result:

   (a) Observation as a team is reduced.

   (b) Enemy gunners can place enfilade fire on the entire flight without changing their position.

(c) The hostile force is alerted by the first helicopter and may either take cover or place fire on the second.

5. Avoid flying parallel to terrain features. Terrain features, such as tree lines, provide good concealment for enemy forces who will normally orient their fields of fire toward the open areas. Continually flying parallel to terrain features establishes a pattern.

6. Always assume the area is hostile. The best approach is to assume that the area is hostile until proven safe, then to continually evaluate tactics and techniques and avoid establishing set patterns.

7. Gather all available intelligence. During the conduct of a mission, an attack helicopter pilot should be constantly looking for new intelligence information and confirming past information.

8. Locate the friendly troops. It is imperative that friendly positions be positively located. Attack helicopter crews will not return hostile fire until the friendly positions are known.

9. Avoid target overflight. Two steps in avoiding overflying the area are:

(a) Engage target at maximum effective range.

(b) Disengage target before reaching enemy's effective antiaircraft range.

10. Conserve ammunition. One method of conserving ammunition is to regularly reserve a certain percentage of the ammunition load for emergencies. This technique should be specified in the unit standard operating procedures (SOP).

11. Take your time. To ensure the application of sound tactics and accurate delivery of fire, a scheme of maneuver must be formulated for any attack. Tactical results are better when time is taken to do the job right.

12. Pull-off. Firing runs should generally be parallel to friendly lines when practicable, and the pull-off executed toward friendlies in such a manner to permit maximum safety for the aircraft and friendly ground troops.

5.8 GENERAL PLANNING CONSIDERATIONS

This paragraph provides information to assist the staff officer and the helicopter pilot in conducting their respective planning for assault support helicopter operations. The material presented in paragraph 5.9 augments the planning guidance and information set forth in FMFM 3-3, Helicopterborne Operations; FMFM 5-1, Marine Aviation; FMFM 7-1, Fire Support Coordination; and the prospective FMFM 5-3 (Initial Draft), Assault Support by identifying those planning factors which are unique to and/or may require special consideration for operations in a high-threat environment. Paragraph 5.11 addresses planning considerations from the viewpoint of the flight leader and individual pilot to aid in determining the tactics to counter the threat and in conducting premission preparations. Reference should be made to the NATOPS flight manual for planning information concerning aircraft performance data and operating procedures. To ensure thorough assault support planning, reference shall be made to each of the three categories of source documents: this manual, the appropriate FMFM publications, and the NATOPS flight manual.

5.9 STAFF PLANNING

5.9.1 General. The key to a successful helicopterborne operation is concurrent planning by the helicopter and helicopterborne units that are actually going to execute the operation. This requires earliest liaison at the executing echelons and subsequent follow-through on integrated planning until the completion of the operation. Often the time available for planning will not be ideal. Therefore, the use of SOPs for routine procedures is desirable. By having SOPs, the limited time available may be devoted to the planning of such variables as scheme of maneuver, selection of helicopter LZs and routes, and fire support coordination. The use of checklists can further expedite the planning process and, more importantly, help to ensure that each area of planning concern has been evaluated systematically. The Helicopterborne Operation Planning Checklist extracted from FMFM 5-3 (Initial Draft) is applicable to both staff level planning and mission planning alike (refer to NWP 55-9-ASH, Tactical Manual, Appendix A).

Since successful accomplishment of the vertical envelopment/helicopterborne assault operation is the fundamental responsibility of the designated commander of the task force formed to conduct the particular operation, he will exercise immediate authority over all aspects of planning and execution. Both the helicopter and helicopterborne unit commanders are responsible for the conduct of detailed, coordinated planning and efficient employment of their respective forces in order to successfully execute the vertical envelopment/helicopterborne assault operation. The assignment of a liaison operations team by the helicopter unit to the supported unit will ensure optimum air response and coordination.

For all other types of operations for which helicopter support is provided, both the helicopter and helicopterborne unit commanders are fundamentally responsible for those aspects of planning and execution of an operation as are applicable to their respective units.

5.9.2 Intelligence Planning. The high-threat environment is deadly and is built around an array of sophisticated weapons. Staff planning must be based on a sound intelligence analysis of the threat which identifies the threat capability and, when possible, identifies enemy air-defense positions. Of primary concern to the assault support planner is the determination of the level of threat which is anticipated, that is, high-threat or low-threat environment. The adoption of a concept of operations, a scheme of maneuver, a fire support plan, and the flight tactics and techniques for helicopterborne operations is dependent on the level of threat which is anticipated. The employment of low-threat environment tactics and techniques in a high-threat environment is an invitation to disaster.

5.9.3 High-Threat Environment. Staff officers planning helicopter operations to be conducted within the enemy air-defense envelope of a high-threat environment must predicate their planning on the fact that a helicopter which can be detected can be destroyed. Operational plans, tactics, and techniques must focus on preventing helicopter detection by enemy air-defense units.

5.9.4 Terrain Flying. Presently, the employment of terrain flying techniques provides the only feasible method for conducting helicopter operations in a high-threat environment. Although other tactical measures and considerations influence helicopter operational planning (e.g., air-defense suppression fires, electronic warfare employment, reduction of helicopter infrared signatures), the basic premise of such planning must be the use of terrain flying techniques, as necessary, to counter the threat through detection avoidance and terrain masking (Figure 5-1).

To successfully employ terrain flying techniques, the helicopter pilot must do more than simply reduce his flight altitude to a level beneath the air-defense envelope. He must solve the problems peculiar to terrain flight, plan his mission thoroughly and navigate accurately, cope with the hazards inherent in low-altitude flight, and fly in a manner that avoids detection and that prevents the enemy gunner from bringing effective fire to bear.

Concomitantly, the staff officer must ensure that his planning efforts assist the helicopter pilot. He must conduct his planning

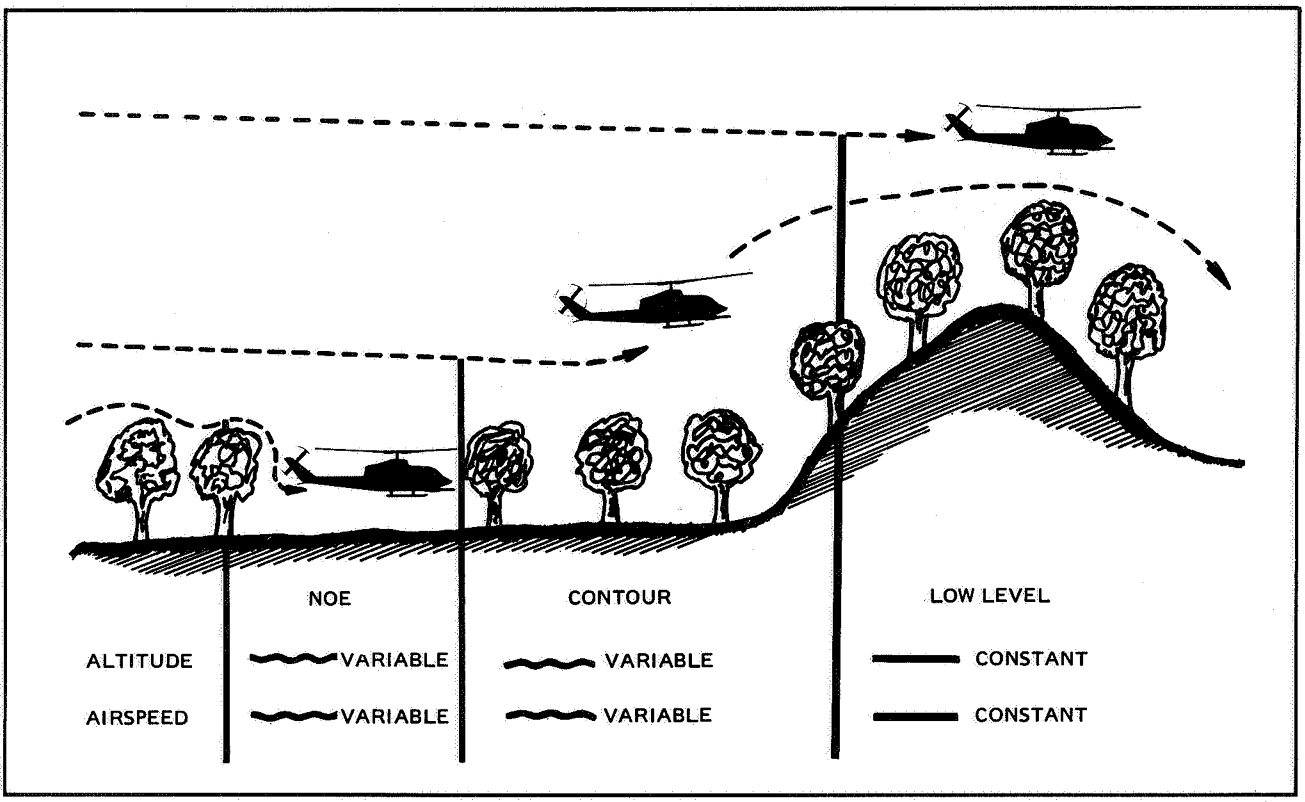


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Figure 5-1. Terrain Flying Profiles

by looking through the eyes of the helicopter pilot; that is, he must formulate a plan that provides detection avoidance, counters the threat, and helps the helicopter pilot conduct terrain flying. As an example, there are situations wherein the terrain does not provide the mask required for detection avoidance. The staff officer must anticipate such situations and plan for the employment of suppressive fires, obscuration means, and any other available support that can screen and protect the helicopter force. Deceptive activity (such as the use of fake LZs and landings, high-altitude activity by fixed-wing aircraft to mask terrain flying penetrations by helicopters, turn-away maneuvers during which a portion of the flight obviously turns back while the remainder descends and continues to the objective below the terrain mask, supporting arms attacks, and assault feints) is an example of innovative planning that can provide surprise and contribute to mission success.

5.9.5 Landing Zone and Approach Retirement Lane Selection. In addition to the criteria set forth in FMFM publications, the planner must evaluate prospective LZs and lanes for terrain flying compatibility. Landing zones should be easy to identify from low altitudes and should provide cover and concealment for helicopters. The avoidance of detection and enemy fire should be two of the governing criteria for LZ and lane selection. LZ selection should be based on the concept of landing just beyond the enemy's detection and weapons engagement range, then maneuvering to attack. LZs should be located where the enemy cannot defend.

Approach/retirement lanes should be based on control points that can be easily identified from low altitudes to facilitate en route navigation. They should be wide enough to permit evasive action and accommodate the meandering flight routes used in terrain flying. They should conform to the terrain to take advantage of terrain masking, rather than be linear in shape and based on direct routing. Alternate routes must be selected based on the threat. Will the postulated threat that could close the primary lane affect the alternate lane? Do the routes unduly channelize and render the flow of traffic predictable?

5.9.6 Command and Control. The use of terrain flying techniques greatly restricts the ability to exercise centralized command and control of helicopterborne assaults through radio communications. The electronic warfare (EW) threat may either completely deny the capability for centralized command and control or make reliance on it ill advised. Planners should consider employing EW-equipped aircraft for standoff relay missions in support of helicopterborne assaults. Operations should be planned and executed with minimum reliance on radio communications. Further, consideration should be given to decentralizing command and control to the HC(A) and helicopterborne unit commander level and to establishing explicit lines of authority to enable the on-scene participants to react as necessary to cope with fast moving tactical situations.

5.9.7 Wave Size and Sequence. Planners should avoid using large wave formations to conduct a helicopterborne assault. Such formations are lucrative targets, unwieldy to maneuver, and not compatible with terrain flying. Rather, numerous small wave formations, two helicopters preferably, should be used at planned intervals that allow flexibility in conducting terrain flying, yet provide a rapid build up of combat power in the LZ. The sequence of events should be timed and controlled to preclude orbiting by the assault support helicopters.

5.9.8 Fire Support. The fire support means available and the capabilities and limitations of each of these systems must be considered during the planning phase. Planners must consider the increased requirement for air strikes and fire missions to suppress air-defense fires in a high-threat environment. This is particularly important during the ship-to-shore movement when fire support means are limited to fixed-wing attack aircraft, attack helicopters, and naval gunfire.

The fire support plan must ensure close and continuous fire support that is compatible with the planned employment of helicopters. In planning the use of supporting arms in a high-threat environment, imaginative use of all resources must be the rule. The key to success will be detailed and thorough planning, coupled with flexible and responsive fire support coordination. Flexibility and responsiveness must be built in at all levels and in all phases of planning and execution.

5.9.9 Electronic Warfare Support. Helicopterborne assaults in high-threat environments should be conducted under the protective coverage of offensive and defensive EW. The full spectrum of EW capability should be employed to disrupt enemy communications, radars, command and control systems, fire control systems, and weapons systems. EW support should be planned and employed as though it were another means of fire support targeted to suppress enemy air-defense efforts and deny the enemy the effective use of EW. EW support should be fully integrated with fire support to ensure a coordinated effort and to obtain the maximum results from both.

5.10 JOINT OPERATIONS

This manual describes how to fight using the attack helicopter. If our past experience holds true for future combat, chances are very good that the USMC will be fighting along with other U.S. and Allied forces. Therefore, a knowledge of how they fight is mandatory. In the area of joint helicopter operations, the requirements for integrating a non-Marine helicopter force into Marine combat operations or vice versa are numerous. Airspace control and coordination, tactics, communications, and logistics procedures must be clearly understood. The lack of common SOPs will required that all operational plans and orders be detailed. The ongoing effort to standardize tactical and logistical procedures and equipment will greatly assist; however, the early exchange of well-qualified personnel is the key to success.

The tactical and logistical procedures encountered when operating with other services or nations are not addressed in this manual. A listing of procedures utilized by the U.S. Army (our most logical combat partner) is in the bibliography and a history of International Agreements in Appendix J.

5.11 MISSION PLANNING

5.11.1 General. The nature of a threat and its intensity dictate which tactics and techniques should be employed to counter that threat at a specific time for a specific mission. In that the potential threat can be categorized into two environments, based on weapons systems capabilities and lethality, so can the basic tactical principles to counter both threats. In a low-threat environment, the tactical concept of employment is to fly above the threat and make rapid, evasive transits through the threat zone. In a high-threat environment the concept is to avoid enemy detecton by flying below the detection envelope and using terrain masking when within the range of air-defense weapons. The determination of which tactics and techniques offer the best chance of mission accomplishment shall be based on careful analysis of the mission, enemy, terrain and weather, and troop (METT) considerations. Particular emphasis shall be placed on evaluating the nature and composition of the anticipated threat and its potential for adverse impact on the mission. The tactics and techniques selected for use shall be tailored to counter the threat environment and must be flexible, innovative, and nonpredictable in application. Detailed premission planning shall be conducted to determine flight tactics and techniques; identify support requirements; and coordinate the employment of fire support, escort support, EW support, and mission command and control. In order for the helicopter pilot to accurately plan and successfully execute his mission, he must be knowledgable concerning the employment of helicopter and fixed-wing escort and other supporting arms.

5.11.2 Threat Analysis. A threat analysis is an examination of the enemy's capabilities and the physical characteristics of the operating environment in terms of the METT factors for the purpose of determining the optimum scheme of maneuver to accomplish the assigned mission. The analysis should be based on timely, evaluated intelligence from all available sources. The threat analysis for each assault support helicopter mission should provide sufficient information for the planners and pilots to identify the threat environment and decide which tactics and flight techniques will be used to counter the threat. The following METT factors shall be analyzed during mission planning.

5.11.2.1 Mission. Conduct a review to ensure a thorough understanding of the scope, objectives, execution, command and control, and coordination details of the assigned mission.

5.11.2.2 Enemy. Conduct a careful evaluation of all available intelligence information to determine the disposition, order of battle, and capabilities of the enemy. This is the primary consideration for determining the anticipated threat environment which, in turn, will dictate the helicopter tactics and flight techniques.

5.11.2.3 Terrain and Weather. Evaluate the terrain in terms of physical characteristics and threat environment to determine approach and retirement routes. If the situation permits and the element of surprise will not be compromised, a visual reconnaissance should be conducted, otherwise, a map and photographic study must be relied upon. Likely targets for supporting arms fire and obscuration shall be identified. In many instances, the weather will be the determining factor as to the tactics and techniques to be employed. Weather should be evaluated in terms of its impact, either pro or con, on both the helicopter scheme of maneuver and enemy capabilities. If not previously established, mission weather minimums shall be identified.

5.11.2.4 Troops. The location of friendly troops, safe areas, and supporting unit capabilities shall be considered. The scheme of maneuver should plan to over-fly safe areas whenever possible and utilize supporting unit capabilities (e.g., fire support, radio relay, radar coverage, navigational assistance, illumination assistance, deceptive activity, EW support).

5.11.3 Altitude Selection. Based on the identification of the anticipated environment, a mission altitude profile shall be selected which minimizes the risk. Altitude selection and approach/retirement route selection are interdependent and shall be considered concurrently to ensure adoption of the optimum scheme of maneuver.

5.11.3.1 Flight Altitudes. Flight altitudes have been divided into two categories based on degree of vulnerability.

1. Low altitude (50-feet terrain/vegetation clearance and below). This altitude regime minimizes the probability of detection and restricts tracking time for all weapons. Small arms, man-portable missiles, and attack helicopters constitute the primary threat.

2. High altitude (1,500-feet AGL and above). Small arms effectiveness is minimized and the effectiveness of air and ground air-defense weapons systems is maximized.

5.11.3.2 Low-Threat Environment. High altitudes should be used to avoid a small arms threat. The decision to use this technique presupposes accurate knowledge of the enemy order of battle and capabilities. When the threat can be accurately identified as to precise location, standoff distance provides the same protection as high altitude. When mission requirements or weather considerations preclude the use of high altitudes, low altitudes should be used.

5.11.3.3 High-Threat Environment. The employment of terrain flying is necessary for mission success in a high-threat environment. Survival depends almost totally on using the detection avoidance and terrain masking concepts of terrain flying. Terrain flying techniques use altitudes in the low-altitude and midaltitude regime as necessary to avoid detection and enemy fire. Terrain flying techniques should not be thought of as employing fixed altitudes, but rather as using whatever altitudes are required to counter the threat. Whether low level, contour, NOE, or a combination of these flight techniques will be used for a mission depends primarily on the threat. Flight safety must also be considered. The higher the altitude, the greater the available reaction time to cope with an aircraft emergency and the less the probability of obstacle or hazard collision. Therefore, terrain flying altitudes should be selected which effectively counter the threat and afford the best available margin for flight safety. That is, the highest altitude below the masking terrain should be used. That portion of a flight conducted beyond the enemy's detection and air-defense envelope should use a high-altitude or midaltitude. As the the flight nears the threat, midaltitude to low altitudes should be used with low level and contour flight techniques. Finally, a mission near or beyond the FEBA (e.g., medical evacuation) should use low altitudes with NOE flight techniques, if required to counter the threat.

5.11.4 Approach and Retirement Route Selection. The threat analysis examination of the METT factors provides the basis of approach and retirement route selections. Route and altitude selections are interdependent and shall be considered concurrently to determine the optimum scheme of maneuver. Avoidance of enemy detection and fire is the primary consideration. In addition to the METT factors, route selection planning shall consider the following general principles:

1. Has the terrain been used to the best tactical advantage?
2. Have primary and alternate approach and retirement routes been identified?
3. Have routes been selected that are easy to identify and navigate?
4. Will communications capability be impaired?
5. Can the routes be used under adverse weather conditions?
6. Have the routes been analyzed to determine points of possible enemy encounter to plan evasive maneuvers or counter action?
7. Do unique support requirements exist for the routes selected?
8. Have supporting arms capabilities and limitations been considered?

5.11.4.1 Low-Threat Environment. The routes used in a low-threat environment should approximate those used in a high-threat environment. In the past, the countertactics for a low threat environment have correctly employed high en route altitudes and standoff distances to avoid the threat; however, the routes utilized were frequently selected more for avoiding friendly fire missions and facilitating navigation through the use of direct routes of flight, rather than tactical considerations. Routes selected on such criteria do not provide the alternative capability to effect a planned and rapid transition to terrain flying techniques to compensate for an unexpected change in threat capability or deteriorating weahter conditions.

5.11.4.2 High-Threat Environment. As previously discussed, terrain flying is the only effective technique to counter a high-threat environment. When selecting terrain flying routes, detection avoidance and protective cover are the governing factors. Terrain flying route selection planning shall consider the following principles in addition to those previously set forth.

1. Keep a terrain mass and/or vegetation between the enemy and the helicopter. Take advantage of masking provided by radar ground clutter.
2. In mountainous terrain, use the friendly side below the crest of the ridgeline.
3. In flat to rolling terrain, use the lowest contours, either ground or vegetation contours as appropriate.
4. Avoid avenues of approach which lead to enemy positions.
5. When paralleling a vegetated area, fly below the crest of the vegetation and close aboard.
6. Avoid built-up areas.
7. Do not follow manmade linear features and avoid using manmade objects as checkpoints.
8. Use heavily vegetated areas as opposed to open terrain. Aircraft shadows are broken and lost in darker vegetation.
9. Avoid silhouetting the aircraft when crossing ridgelines.
10. Know the terrain. Use recent photographic maps whenever possible.

Note

It should be recognized that the terrain will not always provide an effective mask and at times detection must be expected. Mission planning should anticipate such detection and plan for the use of suppressive fires or other support measures (e.g., smoke, chaff, EW measures) to prevent detection and suppress enemy fire.

5.11.5 Deception. Consideration should be given to feints, demonstrations, ordnance/supporting arms employment, or any maneuvers which will mislead the enemy as to aircraft location, routes, and intentions. Possible deceptive maneuvers could include decoy aircraft or formations, loft delivery of 2.75-inch, false transport insertions, and supporting arms fire.

5.11.6 Navigational Considerations. Basic map skills and navigational abilities are essential to the successful completion of the mission in the high-threat environment. The key is to fly under or around the modern enemy threat which means development of navigational skills and new planning considerations. Chapter 6 discusses the various pilot techniques necessary for successful navigation at low altitudes and addresses the crew coordination items unique to flying in this environment.

5.11.6.1 Reconnaissance. Conventional reconnaissance methods such as the visual reconnaissance (VR) will probably not be effective in the high-threat environment. The map/photoreconnaissance will be of primary importance.

5.11.6.1.1 Map/Photo Reconnaissance. When employing TERF tactics, certain problems arise as the altitude decreases requiring a careful map/aerial photo study for topography and enemy information. This the most difficult portion of terrain flight navigation, since little time is available for detailed map study while in flight. Map and aerial photo study would provide the pilot with an advance look at the terrain features he may encounter, ambush positions the enemy may utilize, and terrain he may use for masking. The following considerations for the map reconnaissance are offered as guidelines:

1. Select a map with the desired scale. A large scale 1:250,000 or 1:50,000 is desirable.

2. Checkpoints should be closer together and should utilize natural terrain features rather than manmade objects.

3. Large prominent terrain features can be used as supplemental checkpoints to orient you to your desired flightpath.

4. Key terrain features along the route of flight should be noted, especially altitudes.

5. Limiting points or barriers (easily identifiable features such as railroads, rivers, canals, powerlines, or ridges) should be selected to prevent overflying a turning point or objective area.

6. Select more than one route in and out of the objective area in the event the tactical situation changes.

7. Routes should be selected, to consider performance characteristics and capabilities of individual aircraft (e.g., radius of turn of aircraft should be considered for flight between and around obstacles).

5.11.6.1.2 Photo Reconnaissance. An aerial photograph is simply a photograph of a portion of the Earth's surface, taken from an airborne vehicle. For the purpose of this manual, it will be considered as a map supplement or map substitute. These photographs provide up-to-date information on topographic changes.

As intelligence documents, aerial photographs are frequently the only source of information on enemy-held areas. Unless topographic maps of enemy-held territory are available as a source of information on terrain features, photographs must be depended on entirely for all information about the area and enemy activities, routes of ingress and egress, and so forth.

An evaluation of the relative merits of maps and aerial photographs indicates that each has certain advantages. Therefore, whenever possible, they should be used in conjunction with each other. The following advantages and disadvantages are apparent in the use of photographs alone.

a. Advantages Over a Map

1. They show a wealth of detail that no map can equal.

2. They have accuracy of form. For example, compare the symbol for a church on a map to the picture of the church on the photograph.

3. They are up-to-date. A photograph is ready for use within a few hours after it is taken.

4. They may be made of areas that are inaccessible for military or physical reasons.

5. They show military features that do not appear on maps.

6. They permit a day-to-day comparison of military features, making an evaluation of enemy potentials possible.

7. They provide a permanent and objective record of the day-to-day changes within the area.

b. Disadvantages as Compared to a Map

1. Some features on aerial photographs may be obscured or hidden by other detail, such as a building located in a dense, wooded area.

2. Position, location, scale, and elevations are only approximate.

3. Relative relief is not apparent without the use of special equipment.

4. Lack of color and contrast in tone make photographs difficult to use in poor light.

5. Lack of marginal data on aerial photographs.

6. Aerial photographs require more training to use.

Marine capabilities with relation to photoreconnaissance vary from hand-held cameras to the sophisticated cameras in the RF-4. Coupled with aerial delivery of completed photos to forward operating areas, photo recon can be a versatile tool in mission planning. The photo imagery interpretation unit (PIIU) of the G-2 is tasked to assist in the use of aerial photographs for mission planning.

5.12 HIGH-THREAT COMMUNICATIONS

The use of terrain flying techniques to counter the threat complicates the functions of the attack helicopter commander (AHC) and the other aviation/controlling agencies to communicate with each other.

Terrain masking will severely limit the capability of the flight leader to communicate with control agencies during the execution of the mission.

If limited to line-of-sight communication (e.g., FM, VHF, UHF), the lowest frequency should be selected to achieve the most reliable communications. Although the HF radio is not limited to line-of-sight communication, it is not always reliable. Variations in both the ground and sky wave occur, causing erratic operations.

The use of radio relay should be explored as an alternative solution. The use of detailed time schedules, control points, and phaselines to coordinate supporting elements rather than an "on-call" concept for coordination and execution can partially compensate for communications limitations. A pop-up technique can be used to gain altitude, observe and/or communicate, and return to terrain masking before the enemy can react.

The span of control will be limited by the ability to communicate with supporting and subordinate elements. Inter/intra flight control will ususally be limited to line-of-sight communications.

By constructing a terrain profile, it can be determined at what location along the route radio line of sight can be achieved, if at all. By predetermining these points, prearranged signals can be transmitted as the aircraft pass these positions.

The mission plan should be simple and in sufficient detail that it can be executed without excessive reliance on communications. The use of communications should be reserved for directing the adoption of planned alternative courses of action, directing necessary modifications during mission execution, or coping with emergency situations.

By the use of a prebriefed list of alternate frequencies and a prebriefed code word, necessary transmissions could be accomplished followed by the prebriefed code word which would alert all aircraft in the flight to an automatic frequency shift to the next frequency on the list.

The AHC and associated flight elements should participate as an integral part of the flight. Control must come from within a flight rather than from a command and control aircraft circling high overhead.

Visual communication signals; i.e., color coded Very pistol flares, may be utilized for flight coordination while maintaining radio silence.

The helicopterborne unit commander will no longer be able to use a command and control aircraft to supervise and control the activities of several units simultaneously from altitude. Rather, he will have to use the aircraft as a means of mobility between his units or delegate the final decisionmaking authority to the helicopter unit commander. To ensure the success of the mission, the helicopter unit commander should have extensive knowledge of the helicopterborne commander's concept of operation.

5.12.1 Communications in an Electronic Warfare Environment. Tactical communications on the modern battlefield may be subject to a number of restrictions. These restrictions may be the result of enemy jamming, terrain interference, equipment malfunctions, or the tactical necessity of operating EMCON. This will necessitate the adoption of alternate methods of communication. The methods discussed here deal primarily with visual signals and are best utilized by the AH-1T TOW because of the capabilities of the telescopic sight unit.

5.12.1.1 Hand and Arm Signals. See NWP 55-9-ASH, Vol. I, Chapter 12.

5.12.1.2 Send-A-Message (SAM) System. The SAM system (Figure 5-2) is two sets of five colored numbered flip cards (5" x 8") mounted with four binder rings on a black 8" x 10" blackboard. The cards can be 1/16" plastic, sheet metal, or plastic coated paper. The cards can be imprinted on the back with report formats such as those for SPOTREPS and the Call for Fire.

The SAM set provides 36 combinations of signals/messages that can be transmitted by using the colors numbers shown in Figure 5-2. Additionally, these codes can be transmitted during periods of darkness by indicating the first number with a dot or series of dots and

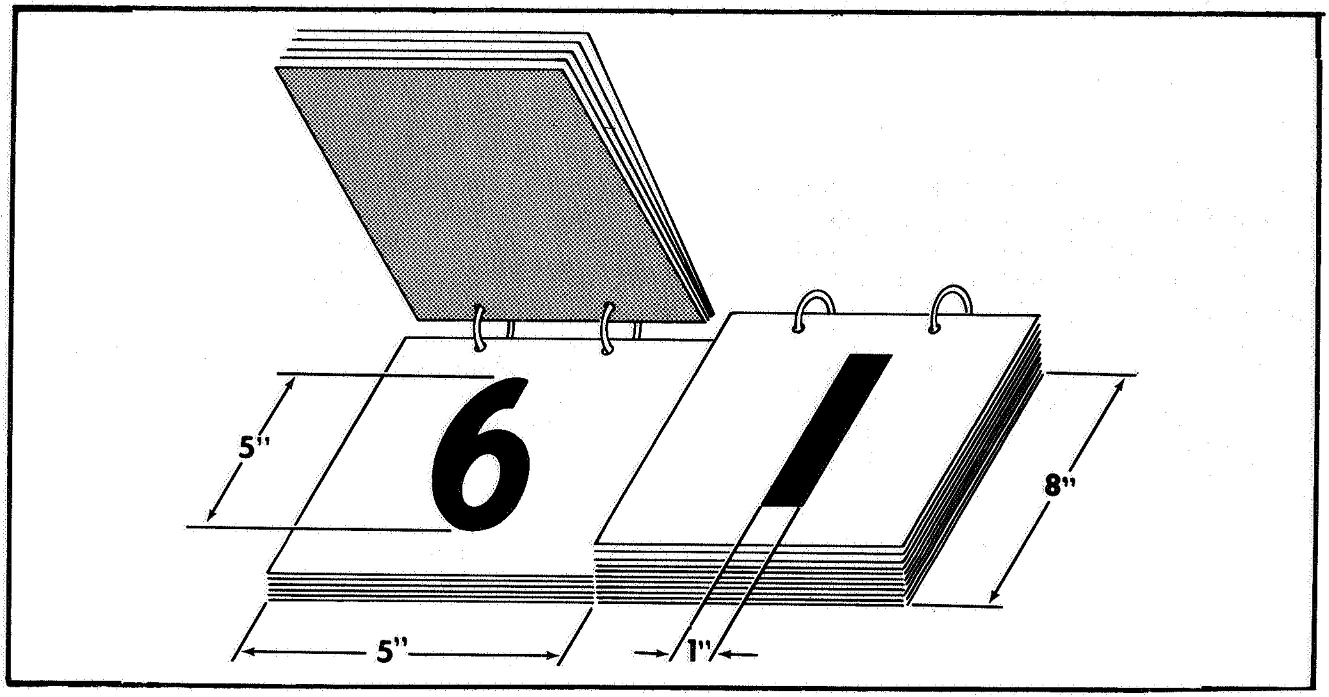

Figure 5-2. Send-A-Message (SAM) System (Sheet 1 of 2)

the second number with a dash or series of dashes. EXAMPLE: "J" should be GREEN/RED or 2-4, thus the first number should be indicated with two dots and the second number with four dashes (../----).

5.12.1.3 Light Signals. Light signals can be used as a means of communication between aircraft. The map light can be used with the clear and red lenses. These signals are very simple and easy to understand, and they should be coordinated between all members of the unit prior to each mission. Examples are as follows:

One white flash.	Follow me
Two white flashes. . . .	This is your firing position (aim in direction of may tail)
One red flash . .	Remain here until I return
Three red flashes . . .	Return to the _*_ area.
*One red flash	Holding area
*One white flash	FARRP
*Two white flashes	Assembly area

Light signals may be very useful at night or during periods of low visibility, but they may have very limited use during daylight.

5.12.1.4 Aircraft Position and Movement. Attack aircraft may be directed around the battle field by a controlling aircraft. Some of the basic signals are as follows:

Nose down, then up.	Start engines/ Prepare for takeoff

	1	2	3	4	5	6
①	A	B	C	D	E	F
②	G	H	I	J	K	L
③	M	N	O	P	Q	R
④	S	Y	U	V	W	X
⑤	Y	Z	AA	BB	CC	DD
⑥	EE	FF	GG	HH	II	JJ

6X6 MATRIX

CARD COLOR/Number Color

1 — BLUE/White
2 — GREEN/White
3 — YELLOW/Black
4 — RED/White
5 — WHITE/Black
6 — BLACK/White

Color Associations

GREEN/GREEN (2-2) = Enemy Ground Troops
YELLOW/YELLOW (3-3) = Armor
RED/RED (4-4) = Danger
WHITE/WHITE (5-5) = All Clear

Code Categories

1-1 thru 1-6 = Instructions
2-1 thru 2-6 = Infantry
3-1 thru 3-6 = Armor/Aviation
4-1 thru 4-6 = Danger/Threats
5-1 thru 5-6 = Description/Locations

SAM DEFINITIONS

CODE	LETTER	A/D	MESSAGE	CODE	LETTER	A/D	MESSAGE
1-1	A	1	Azimuth	4-1	S	19	Aircraft
1-2	B	2	Move, -ing	4-2	T	20	GAS/CBR
1-3	C	3	Check point	4-3	U	21	Artillery
1-4	D	4	Distance	4-4	V	22	Danger, (ADA, ambush)
1-5	E	5	Return	4-5	W	23	Cease fire
1-6	F	6	Follow me	4-6	X	24	Mine(s), -ed
2-1	G	7	Grid	5-1	Y	25	On the road
2-2	H	8	Troops	5-2	Z	26	Camouflaged
2-3	I	9	Squad	5-3	AA	27	Stationary
2-4	J	10	Platoon	5-4	BB	28	Fire
2-5	K	11	Company	5-5	CC	29	All clear
2-6	L	12	Holding position	5-6	DD	30	Friendly
3-1	M	13	Attack helicopters	6-1	EE	31	Bridge/ford
3-2	N	14	BMP/APCs	6-2	FF	32	PZ/LZ
3-3	O	15	Tanks	6-3	GG	33	I spell
3-4	P	16	POL/refuel	6-4	HH	34	Recon
3-5	Q	17	HQ/CP	6-5	II	35	Resupply, class "__"
3-6	R	18	Attack position	6-6	JJ	36	Spare

210900-212-2

Figure 5-2. Send-A-Message (SAM) System (Sheet 2 of 2)

180° turn	Follow me
360° turn	Remain here
Touching skids on ground (Nose in direction of target at each firing position)	Firing position (Attack aircraft moves into position designated by scout) Preplan occupation of multiple positions.
Scouts land, they start ascent	Unmask, acquire, and engage targets.

5.12.1.5 Cockpit Communications. Crew coordination and cockpit teamwork have always been important in the AH-1 helicopter, but they will be even more important in the AH-1T TOW. Figure 5-3 is an example of communications that occur during target handoff from the pilot to the gunner.

Note

> Crew proficiency is enhanced by maintaining crew integrity whenever possible.

5.12.1.6 Radio Communications. While visual signals do constitute a viable alternate means of communicating in an EW environment, the need may still exist to communicate by radio. The folowing are some suggested methods of using a radio while minimizing the enemy's capability of jamming or homing on the signal.

5.12.1.6.1 Brevity Codes. A Brevity Code can be established in a unit's SOP by using the CEOI. This method of communication uses a short word to signify an action; i.e., "RED" — Crank and follow me to firing position. This means of communication requires use of a radio, but the brevity of transmission does not allow the Threat to home-in on your aircraft. This method also requires close coordination between team members prior to the mission. Use of brevity words/phrases also offers an excellent means for "BURST OVERRIDE" of EW jamming.

5.12.1.6.2 Preplanned Frequency Changes. The enemy is capable of denying the use of a radio frequency without the aircrew being

Pilot	Gunner	Item Description
Gunner		Alert.
Tank		Target Description.
On Ridgeline		Visual cue to assist gunner in target location.
	Acquisition	Gunner states when PHS button is released. Indicates TSU has target and that pilot can move his head.
	Tank – T-62	Gunner identifies as either friend or foe.
	Moving left to right	Gunner specifies movement so pilot can plan plan for prelaunch constraints.
	2 mils	Gunner states width, in mils, of target.
	3,400 meters	Gunner uses WERM formula to estimate range.

Figure 5-3. Cockpit Communications

aware of jamming. Preplanned frequency changes are used to enhance intraplane communications with a minimum use of the radios. The techniques that may be used are only limited to one's imagination. The following methods may be used, but it is imperative that whatever method is used, all crews must be thoroughly briefed.

1. Time
2. Phaselines
3. Visual signals
4. Checkpoints.

Note

> Regardless of the method used, it is imperative that all aircraft monitor a common frequency while in the objective area/LZ.

5.13 LOGISTICAL SUPPORT

When physically detached from the parent squadron, responsibility for logistical support planning and coordination rests with the detached unit officer in charge. Since fuel and ordnance availability is critical to the success of the attack helicopter mission, one or more forward area refuel and rearm points should be considered and established whenever feasible. Quick turn-around requirements up to five times a day or more can be routine. Liaison through the parent squadron with Marine Air Group/Wing Supporting Units during early planning stages will ensure timely and effective support for attack helicopter detachments assigned at any level of task organization. Because of the large quantities of fuel and ammunition expended by attack helicopters, ground commanders must be made especially aware of support requirements, to include recommended locations for forward-area rearm/refuel points. FMFM3-3 Helicopterborne Operations and the FMFM 5 Series on Marine aviation set forth doctrinal policy on command and control relationships, assign functional responsibilities, and delineate the coordination efforts necessary to integrate the actions of ground and aviation units.

5.14 MISSION BRIEF

The mission brief is the final phase of the planning effort and should include, as attendees, all mission participants. This brief will set forth the concept of operations, scheme of maneuver, and specific details concerning mission coordination and execution. Information shall be provided which enables each participant to understand the overall operation and his specific role and responsibilities regarding mission execution. Joint briefings with representatives from each participating unit should be used as much as possible. At a minimum, attendees should include the following as appropriate for the assigned mission:

1. HC(A)
2. Helicopterborne unit commander
3. Supporting arms representative
4. TAC(A) or FAC(A)
5. FAC
6. Fixed-wing attack aircraft flight leader
7. Attack helicopter flight leader/flight coordinator
8. Helicopter transport commander
9. AHCs/HACs.

The information developed during the planning effort shall comprise the subject matter for the mission brief. Mission briefers shall use the guides in Figures 5-4 through 5-6, NWP 55-9-ASH, Vol. I, and Section III of the applicable NATOPS flight manuals to satisfy mission briefing requirements.

CLOSE IN FIRE SUPPORT/ANTIARMOR BRIEFING GUIDE

SITUATION

1. General

   Operation area

2. Friendly
   - a. Infantry/armor
   - b. Artillery
   - c. Fixed wing/CAS
   - d. Helicopter
   - e. Naval gun fire
   - f. Fire support coordination lines/areas
3. Enemy

MISSION

1. Overall flight mission
2. Time on target
3. Mission priority

EXECUTION

1. Maps/charts
2. Mission assets/ordnance
3. Callsigns/event numbers
4. Chain of responsibility
   - a. Flight leader/alternate flight leader

Figure 5-4. Close-In Fire Support/Anti-Armor Briefing Guide (Sheet 1 of 6)

CLOSE IN FIRE SUPPORT/ANTIARMOR BRIEFING GUIDE (Cont.)

   b. TAC(A)/FAC(A)

5. Minimum weather
   a. Helicopter
   b. Fixed wing
6. General scheme of maneuver
   a. Overall
   b. Airfield/ship/FARP
   c. Routes
   d. Holding areas
   e. CAS preparation and SEAD
   f. Escort
7. Current and forecast weather
   a. Objective
   b. En route
8. Launch
   a. Turn-up time/frequencies
   b. Taxi time/frequencies
   c. Arming time/location/formation
   d. Takeoff time/frequencies/formations
   e. Communications procedures

Figure 5-4. Close-In Fire Support/Anti-Armor Briefing Guide (Sheet 2 of 6)

CLOSE IN FIRE SUPPORT/ANTIARMOR BRIEFING GUIDE (Cont.)

9. Ingress
    a. Rendezvous
    b. Primary and alternate route/phase lines/checkpoints
    c. Timing
    d. Airspeeds/altitude/flight mode
    e. Formations
    f. Switches and circuit breakers
    g. En route terrains
    h. Probable point of first contact
    i. En route communications procedures
    j. Minimum aircraft required to continue mission (Go/No Go)
    k. Enemy ground fire procedures
    l. Aircraft lighting
    m. Authority to change routes
10. Holding area(s)
    a. Formation/coverage
    b. Briefing method
11. Attack position
    a. Firing points/covering points
    b. Firing method
    c. Firing sequence
    d. Ordnance expenditure

Figure 5-4. Close-In Fire Support/Anti-Armor Briefing Guide (Sheet 3 of 6)

CLOSE IN FIRE SUPPORT/ANTIARMOR BRIEFING GUIDE (Cont.)

12. Egress
    a. Primary and alternate route/phase lines/checkpoints
    b. Timing
    c. Airspeeds/altitude/flight mode
    d. Formations
    e. En route terrain
    f. Probable point of last contact
    g. En route communications procedures
    h. Aircraft lighting (if different from ingress)
    i. Authority to change route
13. Penetration point
    a. Airspeed/altitude
    b. IFF
14. Supporting arms
    a. Ingress/assault
    b. Egress
15. Evasive maneuvers/scatter plan/rendezvous
16. Downed aircraft
    a. Sea
    b. Ashore
    c. Ingress/egress/holding area/attack position

Figure 5-4. Close-In Fire Support/Anti-Armor Briefing Guide (Sheet 4 of 6)

CLOSE IN FIRE SUPPORT/ANTIARMOR BRIEFING GUIDE (Cont.)

   d. Simulated/actual
   e. SAR/E&E

17. Rules of engagement
18. Other operations
19. Fuel
    a. Minimum/Bingo
20. Electronic warfare
    a. ALQ-144/APR-39/ALE-39
    b. CHATTERMARK procedures
    c. Deception/meaconing
    d. MIJI reporting
21. Inadvertant IMC/loss of visual contact
    a. En route
    b. Target area
22. Emergencies
23. Lost/no-communication procedures

ADMINISTRATIVE

1. Safety
2. Time hack
3. Debrief place/time
4. EEIs

Figure 5-4. Close-In Fire Support/Anti-Armor Briefing Guide (Sheet 5 of 6)

CLOSE IN FIRE SUPPORT/ANTIARMOR BRIEFING GUIDE (Concl.)

5. Mission essential equipment
6. Other

COMMAND/SIGNAL

1. Controlling agencies
2. Frequencies
   a. UHF
   b. FM
3. Frequency changes
4. EMCON procedures
5. DRIADS
6. Code words
7. Aircraft signals
8. Ground signals
9. IFF

Figure 5-4. Close-In Fire Support/Anti-Armor Briefing Guide (Sheet 6 of 6)

FLIGHT COORDINATOR'S BRIEF

1. THE LEAD ATTACK HELO COMMANDER OF THE ESCORT FLIGHT IS DESIGNATED BY THE HELO TRANSPORT COMMANDER TO ASSUME THE DUTIES OF FLIGHT COORDINATOR WHICH INCLUDE:

   A. LZ IDENTIFICATION
   B. LZ PREP
   C. EN ROUTE CLEARANCES
   D. COMMUNICATIONS

2. THE FLIGHT COORDINATOR WILL BRIEF THE FLIGHT UTILIZING THE FOLLOWING GUIDE:

   A. PRELAUNCH

      (1) ATTACK HELO TURN-UP TIME AND FREQ
      (2) ATTACK HELO FUEL AMOUNT
      (3) PREBRIEFED ATTACK HELO ORDNANCE
      (4) PREBRIEFED ATTACK HELO EQUIPMENT NECESSARY FOR MISSION

   B. EN ROUTE

      (1) FREQ CHANGES
      (2) CONTROL AGENCY CLEARANCES
      (3) ATTACK HELO FORMATIONS
      (4) ATTACK HELO EVASIVE ACTIONS
      (5) INADVERTANT IMC
      (6) NAVIGATION

   C. LZ

      (1) TYPE APPROACH
      (2) COVER PATTERNS
      (3) SUPPRESSIVE FIRES
      (4) FIXED-WING AND FIRE SUPPORT COORDINATION
      (5) ORDNANCE UTILIZATION
      (6) LZ CRITERIA
      (7) TRANSPORT GUNNER PROCEDURES

Figure 5-5. Flight Coordinators Brief Guide

LANDING ZONE BRIEF

1. MISSION NO. ________________

2. LOCATION
   COOR/RAD/DME ________________

3. UNIT CALL SIGN ________________

4. FREQUENCY PRI UHF ________ FM ________
   SEC UHF ________ FM ________

5. LZ MARKING ________________

6. WIND DIRECTION/VELOCITY ________ / ________

7. ELEVATION/SIZE ________ / ________

8. OBSTACLES ________ ________

9. FRIENDLY POSITIONS:
   DIRECTION/DISTANCE ________ / ________

10. ENEMY POSITIONS:
    DIRECTION/DISTANCE ________ / ________

11. LAST FIRE RECEIVED:
    TIME/TYPE ________ / ________

12. DIRECTION OF FIRE/DISTANCE ________ / ________

13. CLEARANCE TO FIRE:
    DIRECTION/DISTANCE ________ / ________

14. APPROACH/RETIREMENT
    (RECOMMENDED) ________ / ________

15. PERSONNEL/EQUIPMENT ________ / ________

16. OTHER ________________

Figure 5-6. Landing Zone Brief

5.14.1 Close-In Fire Support/Anti-Armor Briefing Guide. This guide shall be used for all missions in which CIFS/anti-armor is the primary mission and the Mission Briefing Guide in NWP 55-9-ASH, Vol. I is not used.

5.14.2 Zippo Brief. The Zone Inspection, Planning, Preparation and Operation Evaluation Brief is a face-to-face conference of the helicopterborne unit commander, the helicopter element commander, and key staff members who jointly plan a helicopterborne operation in which their units are participating. This brief will discuss all items found in Figure 5-4, to include aircraft performance in relation to anticipated tactic, threat, and load factors.

5.14.3 Aircrew Brief. Frequently, not all aircrew members can attend mission briefs. The preflight duties of the crewchief and gunners normally preclude their attendance. Prior to takeoff, the AHC/HAC shall brief his aircrew members. At a minimum, this briefing will include the information contained in Figure 5-5.

5.14.4 Landing Zone Brief. The information in Figure 5-6 should form the basis of the brief given to the attack helicopter commander and to the transport helicopter landing in the landing zone.

Landing zone brief radio transmissions will be addressed by line number. Unknown or not applicable line numbers will be referred to as *negative*. For example:

Line One — Negative

Line Two — 986321

Line Three — CE3

Line Four — Negative

Etc.

5.15 MISSION COORDINATION, COMMAND, AND CONTROL

FMFM 3-3 Helicopterborne Operations and the FMFM 5 series on Marine aviation set forth doctrinal policy on command and control relationships, assign functional responsibilities, and delineate the coordination efforts necessary to integrate the actions of the ground and aviation units participating in helicopterborne operations during the amphibious assault and subsequent operations ashore. The following information concerning such relationships has been assembled from the referenced source documents and is published in this manual to assist aircrews in understanding the general concepts of coordination, command, and control for assault support helicopter operations. Reference shall be made to the appropriate FMFM publication to resolve questions concerning general doctrine or policy matters and to the effective operation plan or order to resolve questions concerning a specific opera- tion.

5.15.1 Helicopter Unit Commander. The helicopter unit commander is the senior Marine aviator designated commander of the helicopter unit tasked to support a helicopterborne operation. He is responsible for his unit's performance. His unit is a component part of the landing force and is under command of the commander landing force. He is responsible for establishing liaison with the helicopterborne unit commander to conduct concurrent and parallel planning.

5.15.2 Helicopterborne Unit Commander. The helicopterborne unit commander is the ground officer who has been designated commander of the helicopterborne force and is charged with the accomplishment of its ground mission. His unit is a component part of the landing force and is under command of the commander landing force.

5.15.3 Tactical Air Coordinator (Airborne). The TAC(A) is an experienced aviator airborne in the area of operation in a helicopter or fixed-wing aircraft. His primary responsibility is to coordinate and direct the activities of aircraft assigned to him and to report to the appropriate ground and air control agencies in his area of responsibility. The coordination function may involve the handling of a variety of aircraft or integrating air activity between helicopters and conventional aircraft as in a helicopterborne assault, landing zone preparation, resupply, or other air activity. A secondary mission of the TAC(A) is the detection and destruction of enemy targets through close or deep air support. The TAC(A) should also have a thorough understanding of supporting arms coordination and artillery/naval gunfire spotting procedures. Normally, the high-performance jet is not as effective for use in the TAC(A) role as slower aircraft types because of performance characteristics. The high-performance aircraft's advantage lies in its ability to survive in a high-threat area because of speed and ECM equipment, its compatibility with a high-performance strike aircraft, and its air-refueling capability. A slow mover's advantage, as the term implies, lies in the ability to move over the area at a relatively slow rate of speed, thereby providing the TAC(A) better maneuverability and observation. In the performance of his mission, the TAC(A) performs the following tasks within his assigned area of responsibility as each situation dictates:

1. Coordinates the activities of all aircraft in his assigned area of responsibility.

2. Coordinates direct air support missions with the fire and movement of friendly ground units.

3. Coordinates the activities of FAC(A).

4. Coordinates the assignment of aircraft to FAC(A).

5. Advises FAC(A)s and HC(A)s of weather.

6. Advises FAC(A)s and HC(A)s of enemy operations.

7. Detects enemy targets for neutralization or destruction.

8. Controls close and deep air support missions when directed.

9. Controls artillery and naval gunfire missions when required.

5.15.4 Forward Air Command (Airborne). The FAC(A) is an air controller airborne in the area of operations in a helicopter or fixed-wing aircraft. The primary function of the FAC(A) is the detention and destruction of enemy targets both in close and deep air support. The FAC(A) role may be encompassed within the TAC(A) mission above but normally does not require the degree of experience demanded of that function. The FAC(A) may be assigned directly to support a given ground unit or he may be assigned directly to a TAC(A) or an HC(A) to provide air control as required on various types of operations. The FAC(A) should have a working knowledge of fire support coordination precedures, visual reconnaissance, and artillery/naval gunfire spotting techniques. In the performance of his mission, the FAC(A) performs the following tasks within his assigned area of responsibility as each situation dictates:

1. Detects enemy targets for neutralization and destruction.

2. Controls close air support missions.

3. Controls deep air support/interdiction missions when directed.

4. Controls landing zone preparations.

5. Controls armed helicopter fire suppression missions.

6. Marks targets and landing zones.

7. Controls artillery and naval gunfire missions when required.

8. Visual reconnaissance.

9. Reports intelligence information to the appropriate ground or air control agency.

5.15.5 Naval Aviation Observer (NAO) — a ground officer trained as an air observer operating from an observation aircraft whose primary mission is to provide tactical commanders with information relative to the enemy forces, terrain, and hydrography, and to direct supporting fires for ground forces to include artillery, naval gunfire, and close air support.

5.15.6 Helicopter Coordinator (Airborne). The HC(A) is an experienced aviator, knowledgeable in all aspects of helicopter operations, delegated the specific responsibility of airborne coordination and control of helicopters while en route and within the objective area. During the ship-to-shore movement, the HC(A) operates under the control of the Helicopter Direction Center (HDC) which is shipborne. The HC(A) may be assigned responsibility for certain command aspects of the helicopter assault and further coordinates with the TAC(A) for activity in the vicinity of the landing zone. When the control of helicopters is passed ashore, the direct air support center (DASC) assumes control of helicopter operations. When control is assumed by the DASC, the HC(A) continues to assist in the control of the DASC if needed. Normally, an HC(A) will be assigned for the initial assault and will be airborne within the objective area in a command and control (C&C) helicopter. The helicopter transport commander shall act as HC(A) when an HC(A) has not been assigned. In the performance of his mission the HC(A) performs the following tasks as required by each situation:

1. Be an active participant in the planning phase and be thoroughly knowledgeable in every fact of the operation.

2. During the preparation phase, request the assistance of observation and tactical support aircraft as needed through the DASC and appropriate TAC(A).

3. During the execution phase, be airborne in the same C&C helicopter with the helicopterborne unit commander for the purpose of arriving at timely and coordinated decisions such as final selection of landing zones and the selection of landing zones for succeeding waves, if required.

4. Conduct airborne coordination and control of helicopters which are en route to and within the objective area.

5. Coordinate the activities of assigned TAC(A)s, FAC(A)s, and/or NAOs. The HC(A) will ensure that the fixed-wing preparation strikes, controlled by the FAC(A)s/NAOs, are accurately conducted and are timely and sufficient.

6. Advise the TACC and HDC on the status of the landing to include any changes made in landing zone utilization.

7. Provide information concerning weather along the approach and retirement routes and in the landing zones, enemy observations along the approach and retirement routes, alterations to the helicopter route, and employment of supporting arms.

5.15.7 Helicopter Transport Commander — an experienced aviator in command of the assault support helicopter flight taking part in a helicopterborne mission. He shall function as the HC(A) for missions when no HC(A) is assigned.

5.15.8 Flight Leader — an attack helicopter commander (AHC) or helicopter aircraft commander (HAC) designated in writing as a flight leader by the helicopter unit commander. In mixed flights, including assault support helicopters and attack helicopter escorts, the overall flight leader is the helicopter transport commander.

5.15.9 Flight Coordinator. An experienced attack helicopter commander of the escort flight is normally designated by the helicopter transport commander to coordinate assets during the insertion and extraction of assault support helicopters. Unless specifically briefed otherwise, the senior attack helicopter commander of the flight will assume the following duties of the flight coordinator: navigation, en route flight clearances, landing zone identification, landing zone preparation, communications, coordination, etc., and other duties directed by the transport commander. Utilization of flight coordinators is particularly effective on resupply and medical evacuation missions where expediency is necessary, on reconnaissance patrol insertions/extractions where minimal transport helicopter exposure is desirable, and on assaults where multiple landing zones are used.

Note

In a sophisticated threat environment, if the flight coordinator is tasked with navigation responsibilities, protective coverage of the transports will be significantly degraded.

CHAPTER 6

Escort

6.1 GENERAL

Escort of friendly units by armed helicopters falls into two basic categories: helicopter escort and surface force escort. Helicopter escort generally involves escort for missions such as troop assault, medevac, resupply, and other helicopter operations. Surface force escort involves providing armed helicopter escort for land or waterborne convoys, as well as for ground unit operations.

6.2 HELICOPTER ESCORT

The same basic principles apply to the escort of assault support helicopters during troop assault, medevac, resupply, and reaction/reconnaissance team missions.

Attached escort is the most commonly used type of helicopter escort and involves attaching the armed helicopters with the escorted unit. The armed helicopters will provide visual and weapons coverage for the escorted unit, providing responsive suppressive fires for any threat engagement. The principle of suppression is to degrade the effectiveness of enemy combat power for a period of time. Because of the forward employment of sophisticated antiaircraft weapons, aviation units cannot count on surviving on the battlefield if they expose themselves more than momentarily to weapons that have not been destroyed, suppressed, or obscured. Attached escort cover patterns may be flown in a variety of ways, but there are certain prerequisites that must be satisfied:

1. Provide flexibility to the escort helicopter so that he can react rapidly to hostile fire.

2. Provide maximum protection to the escorted helicopters.

3. Provide for mutual support of the escort helicopters when possible.

4. Facilitate ease of control by the flight leader.

Detached escort entails the use of armed helicopters which provide escort coverage for an escorted unit not attached to that unit. These escort helicopters provide protection by either clearing a path in advance of the transport helicopters (sweep escort), or by rendezvousing at predetermined points along a route with them. At times, coverage of only key sectors along a route of flight may be required, and in this way, armed helicopters may provide shuttle escort from key point to key point, providing protection for many helicopters in a given area of operations. If a desired escort to transport ratio of 2:3 cannot be achieved, or METT considerations provide disadvantageous conditions for attached escort, detached escort coverage can be provided to allow safe transit for assault support helicopters. This can achieve maximum effectiveness only if detailed flight planning is accomplished. Routes, phase lines, and predetermined checkpoints must be fully understood by every member of the flight. Position awareness is extremely critical when using detached escort. A scatter plan and brevity list of code words are required for directing the helicopter escort or the transports, changing routes, or adjusting timing at the LZ(s). Since escort response time is of the utmost importance, due consideration should be given to limiting the forward travel of the escorts. If threat conditions are not expected to significantly change along the route of flight, however, the escorts may be sent to clear the entire route prior to the departure of the escorted unit, and then return to provide attached escort support. If a static situation cannot be assured, a preferred method would be to launch the escorts at a predetermined time before the transport flights, and have them maintain a fixed but flexible separation preceding the transports. Primary considerations should be based on METT.

Timing is critical for shuttle escort. Proper airspeed and route management can allow escort aircraft to rendezvous with transport flights at key points along the route where the probability of enemy contact is highest. This provides immediate physical coverage for the escorted unit when it is needed most. Once the transport helicopters reach the limits of the last relatively safe area, they are joined by their escorts, who shuttle them in and out of the LZ(s), providing terminal escort coverage. METT considerations may dictate contour or nap-of-the-Earth (NOE) flights; therefore, a bounding overwatch may be necessary. Multiple ingress and egress routes are essential to eliminate continued overflights of an area. Properly placed escort helicopters in overwatch areas can provide mutual support for each other as well as for multiple transport flights in the terminal phase of their ingress. Rapid massing of combat power in an LZ may not always be possible if escort helicopters are few in number unless shuttle escort is used.

Use of fixed-wing assets is desirable to provide CAP/CAS support. Even though escort helicopters can be equipped with air-to-air missiles, the best defense against alerted hostile fixed-wing aircraft is friendly fighters. Route checkpoints, phaselines, and code words must be briefed and understood in order to to enable rapid, accurate response. A barrier combat air patrol (BARCAP) is most commonly used by friendly fighters to protect an area from an air threat. An escort by fixed-wing aircraft, in addition to attached helicopter escort, can be employed.

6.2.1 Assault Helicopter Escort. The responsibility for the control and coordination of large helicopter assaults should be centralized and is normally vested with a helicopter coordinator (airborne) (HC(A)). He will exercise his control of the helicopters involved through the various flight leaders and will normally pass the control of the fixed-wing aircraft and other supporting arms to a tactical air coordinator (airborne) (TAC(A)). An HC(A) is normally designated for helicopter assaults. If no HC(A) or TAC(A) is appointed, the flight leader of the transport helicopters will be vested with the same responsibilities. He will normally, in turn, pass the control of the assets involved to the attack helicopter flight leader, but will retain the prerogative of taking control himself any time he feels that it is in the best interest of the flight. In all helicopter assaults there are three aspects that should be considered: the route, the organization of the landing zone, and the final approach and retirement (Figures 6-1 through 6-4).

6.2.2 Resupply Escort. The flight will report to the combat service support area (CSSA) where the flight will be given a schedule of the units to be resupplied, the off-loads that each unit will receive, the location of the unit, and the time schedule for receipt of supplies. If the escort helicopters are not required to accompany the transport helicopters to the zone, they will depart and proceed to the area where the resupply will take place. The escort helicopters will request necessary clearances for the flight to the resupply area. Radio communications should be established with all units receiving resupply, and a complete landing zone brief requested. In addition, the ground unit should be alerted to stand by for resupply. The escort helicopters should verify the location of the zone and the position of all friendly units in the area and be prepared to pass all information to the transport helicopters as they arrive in the area. The approach and departure will be conducted in the same manner as a medevac or troop assault. Particular care should be taken during resupply missions to avoid complacency during repeated approaches to the same zone.

6.2.3 Medevac Escort. The medevac mission is unique in that there normally is a minimum amount of time for planning and there are

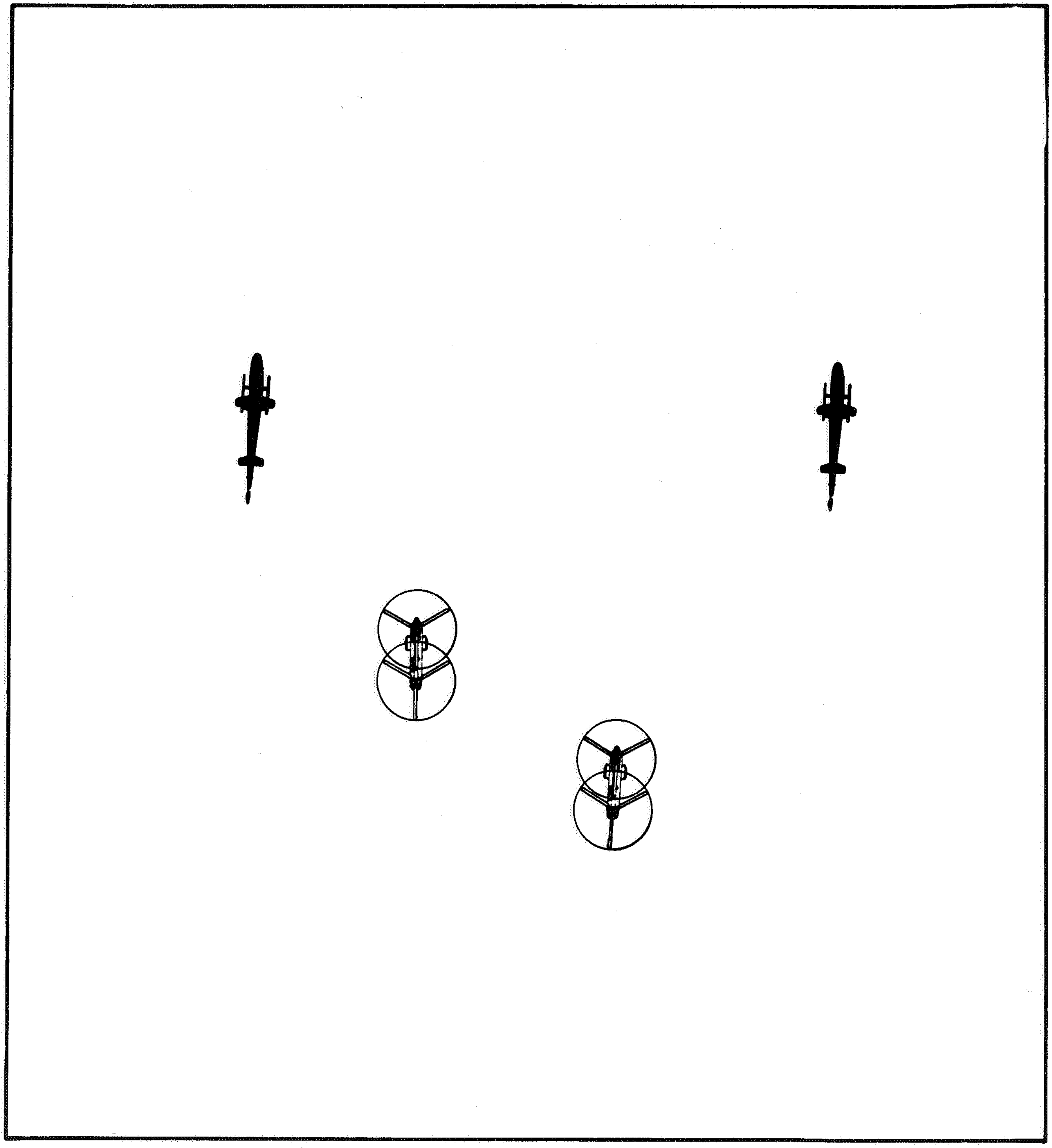

Figure 6-1. 10/2 O'clock Escort Pattern

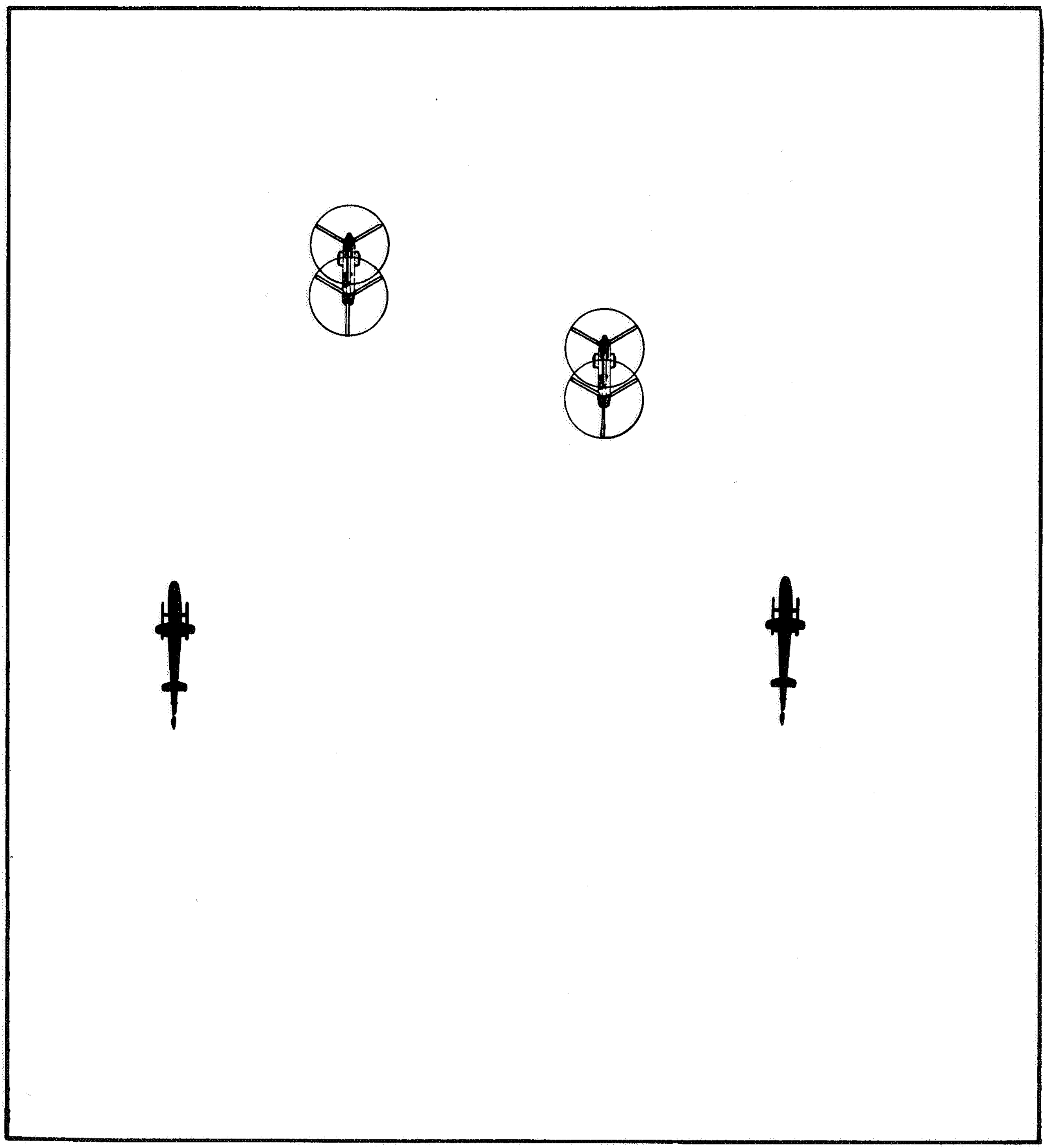

Figure 6-2. 5/7 O'clock Escort Pattern

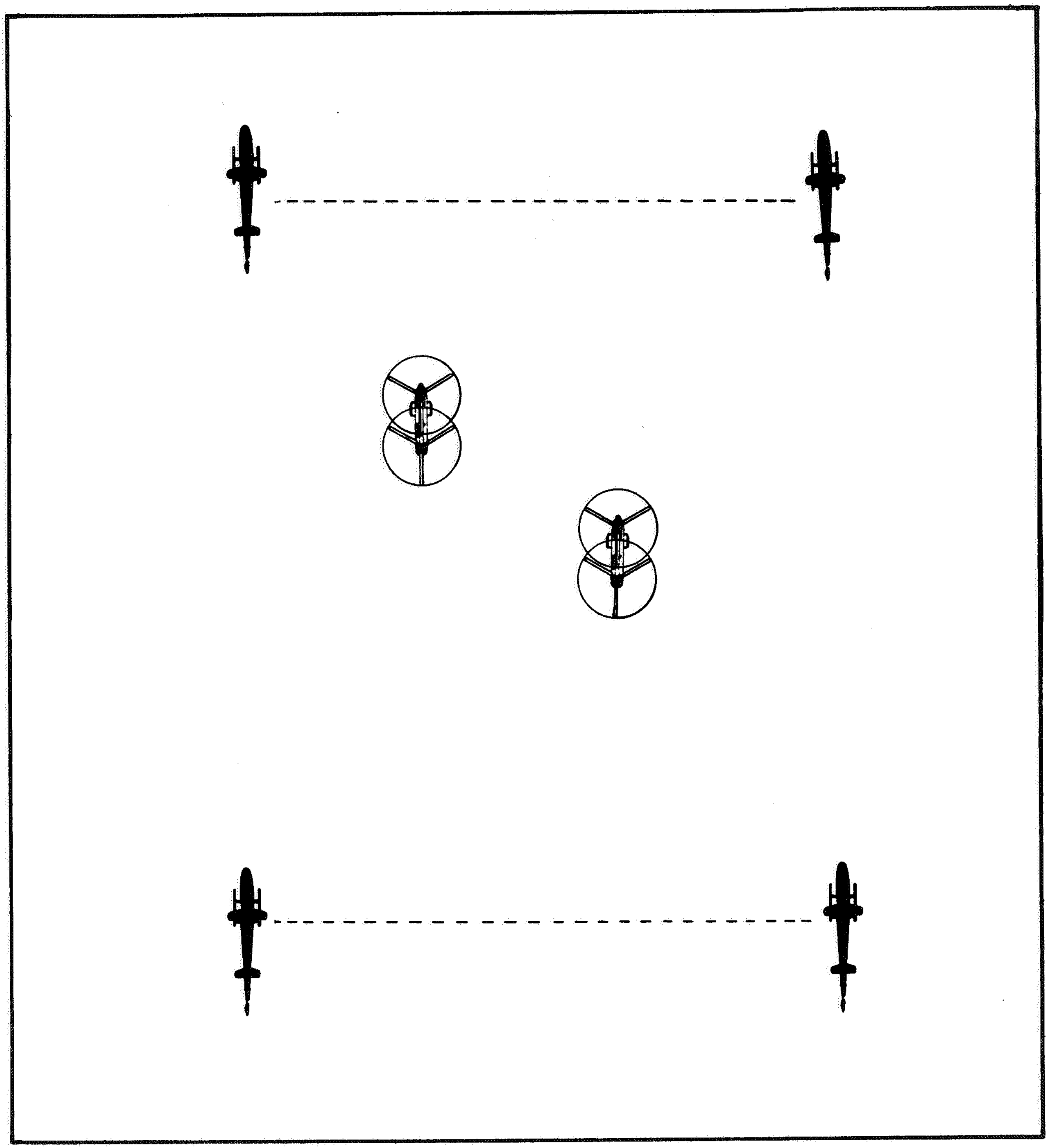

Figure 6-3. 2/7 and 10/4 Escort Cover Pattern

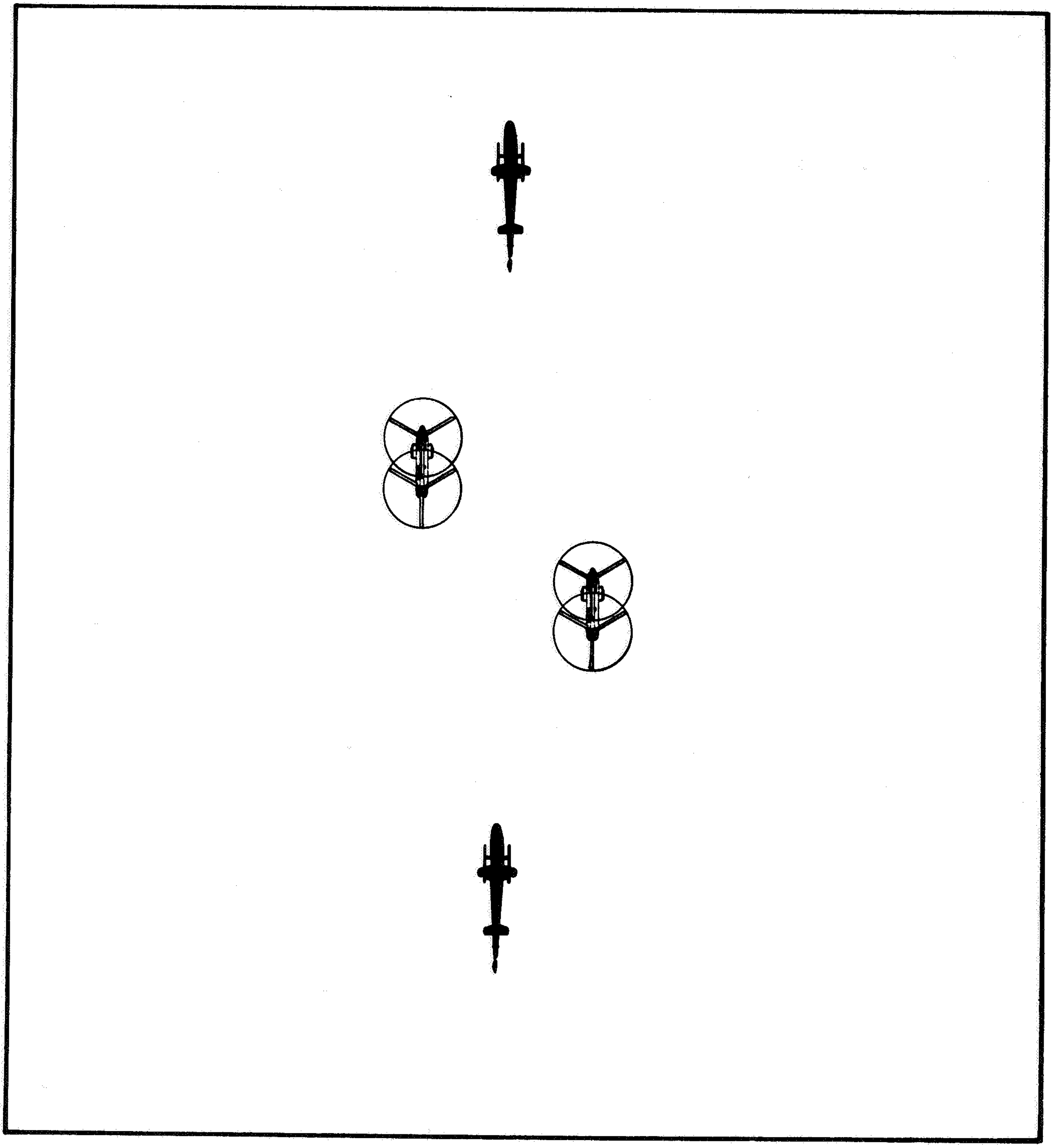

Figure 6-4. 12/6 Escort Cover Pattern

usually large numbers of units to be supported. Whether airborne or on a ready standby condition, the flight must react rapidly to the request for a medevac mission. The brief is normally passed to the flight using a standard format (Figure 7-5). When tasked as flight coordinator, the attack helicopter pilot will request all required clearances from appropriate controlling agencies to the location of the unit requesting the medevac. Once the clearance is received, the flight will switch to the frequency that will be used for the medevac mission; initial contact with the ground unit should include an LZ brief while en route to the pickup zone. En route escort patterns will be used as necessary. Upon arrival at the zone, the attack helicopter pilot should verify the positions of all ground units in the area and determine the recommended direction of approach to be used by the transport helicopter. Depending upon the enemy situation in the area, the attack helicopter pilot may be required to request supporting arms to suppress enemy fire or to make suppressive firing runs himself. He may also request that the ground unit provide a base of fire in conjunction with his fires to protect the transport.

Consistent with the priority of the mission, the attack helicopter pilot should utilize all available fire support assets to minimize the exposure of the transport helicopter to enemy fire during its approach. The final phase of the mission begins when the transport helicopter starts its approach to the landing zone. The ground unit will identify its position and the escort helicopters will position themselves to cover the transport helicopter using the appropriate cover pattern. Once the medevacs are on board the transport, the attack helicopter will cover the departure from the landing zone and provide navigational information as tasked while covering the transport to a safe area or altitude.

6.2.4 Reaction/Reconnaissance Team Escort. Reaction and reconnaissance team escort missions can be flown with any number of aircraft, depending on the size of the force to be inserted. These missions will normally be preceded by a ZIPPO brief covering all the required information. These operations are geared to exploit enemy weakness or to gather intelligence and are normally conducted for a short duration. The procedures for conducting these missions are the same as for other helicopter missions, except that the contingency for a rapid withdrawal or extraction must be completely briefed and understood by all of the participating units. If rapid extraction is deemed necessary, it will normally be done under enemy pressure and must be executed with speed and precision to ensure the success of the mission and the safety of the transport aircraft and all personnel.

The importance of detailed, timely, and concurrent planning between the participating helicopter and reconnaissance units for helicopterborne reconnaissance patrol operations cannot be overemphasized. The transport commander and the escort flight leader are responsible for establishing liaison with the requesting reconnaissance unit. The requesting reconnaissance unit commander will present a ZIPPO brief for the conduct of the operation. In order to facilitate planning and reduce time near the objective area during the insertion, an aerial reconnaissance of the objective area by the transport commander, gunship commander, and the participating reconnaissance team leader should be conducted if possible. Additionally, aerial photos are most beneficial for use in briefing all reconnaissance patrol operations. The conduct of the operation must be satisfactory to all units. When agreement cannot be reached, the matter will be referred to higher authority for resolution.

The helicopter transport commander is to verify the landing zone as correct and approve alternate landing zones as required. Overall responsibility for mission accomplishment rests with the transport commander. He will make the final decision to execute or abort the insert.

Every attempt must be made to conceal intentions, mislead the enemy, and perform the unexpected in carrying out helicopterborne reconnaissance patrol insertions and extractions. Ingenuity and teamwork by all participants are essential for successful mission accomplishment.

6.2.5 Utility Escort. There are a variety of other missions that may require the use of attack helicopters in the escort of utility helicopters in the conduct of their assigned missions (i.e., VIP, command and control, specialized surveillance). The basic principles discussed previously apply equally to these missions. Consideration must be given to the escorted unit's capabilities and the situation.

6.3 SURFACE FORCE ESCORT

The primary objective of the attack helicopter during a convoy escort of ground or waterborne units is to deny the enemy the opportunity to ambush, mine, or block the friendly unit's movement. If the enemy does make contact, the helicopters will attack and suppress the enemy's assault.

The attack helicopters will establish radio contact with the escorted unit upon arrival, inform them of ordnance on board and time remaining on station, and then commence the escort mission.

If the intended purpose of the convoy or ground unit is to draw fire, the helicopters should not be in the immediate vicinity, but should be able to arrive quickly on the scene. If the mission is not planned to last for more than the helicopter's on-station time, an orbit should be set up out of the area, out of sight. If the mission will last longer than the normal on-station time, the flight should be pre-positioned at a nearby airfield or holding area. If a staging area is required for the escort helicopters, local security, communications, and landing signals must be arranged in advance of the mission. Communication with the convoy should be maintained.

The escort helicopters should reconnaissance the area ahead and to the flanks, and then return to the best position from which to escort the unit through the cleared area. This technique is employed in a leap-frog manner until the escorted unit safely reaches its destination.

6.4 PLANNING

Successful escort depends on close coordination among all parties. Detailed planning is essential for all phases of escort operations. When the urgency of the situation precludes normal planning, unit SOPs and training must be relied upon. Escort briefings are mandatory and shall include rendezvous points, communications, navigation points, assets, LZ positions, threat code words, and go-no-go criteria. Tactics, routing, and possible threat encounters/reactions must be understood by all.

6.4.1 Routes. The threat analysis examination of the METT factors provides the basis for approach and retirement route selections. Route and altitude selection are interdependent and shall be considered concurrently to determine the optimum scheme of maneuver. Avoidance of enemy detection and fires is the primary consideration. In addition to METT, the following general principles should be considered.

1. Has the terrain been used to the best tactical advantage?

2. Have the primary and alternate approach and retirement routes been identified?

3. Have routes been selected which are easy to identify and navigate?

4. Will communications capability be impaired?

5. Can the routes be used under adverse weather conditions or at night?

6. Have the routes been analyzed to determine points of possible enemy encounters, and to plan evasive maneuvers or counteractions?

7. Do unique support requirements exist for the routes selected?

8. Have supporting arms capabilities and limitations been considered?

9. Has a counterair plan (helicopter/fixed wing) been devised?

6.4.1.1 Permissive Threat. The routes used in a permissive threat environment should approximate those used in a sophisticated threat environment. In the past, the countertactics for a permissive threat environment have correctly employed high en route altitudes and standoff distances to avoid the threat; however, the routes used were frequently selected more for avoiding friendly fire missions and facilitating navigation through the use of direct routes of flight, rather than tactical considerations. Routes selected on such criteria do not provide the alternative capability to effect a planned and rapid transition to terrain flying techniques to compensate for an unexpected change in threat capability or deteriorating weather conditions. The use of high altitudes and stand-off distances in a permissive threat environment greatly facilitates the execution of the command, coordination, and control functions of the HC(A) and helicopterborne unit commander. The use of high altitude improves communication and enables the HC(A) and helicopterborne unit commander to remain overhead in the objective area to exercise control from a position external to the flight executing the mission. It should be noted that in today's SAM rich environment, many Third World armies are well equipped with both handheld surface-to-air missiles and accurate AAA weapons sytems. The decision to utilize low-threat tactics and formations must be cautiously weighed by the mission commander.

6.4.1.2 Sophisticated Threat. As previously discussed, terrain flying is the only effective technique to counter a high-threat environment. When selecting terrain flying routes, detection avoidance and protective cover are the governing factors. Terrain flying route selection planning shall consider the following principles in addition to those previously set forth:

1. Keep terrain mass and/or vegetation between the enemy and the helicopter. Take advantage of masking provided by radar ground clutter.

2. In mountainous terrain, use the friendly side below the crest of the ridgeline.

3. In flat to rolling terrain, use the lowest ground or vegetation contours as appropriate.

4. Avoid avenues of approach which lead to enemy positions.

5. When paralleling a vegetated area, fly below the crest of the vegetation and close aboard.

6. Avoid built-up areas.

7. Do not follow manmade linear features and avoid using manmade objects as checkpoints.

8. Use heavily vegetated areas as opposed to open terrain. Aircraft shadows are broken and lost in darker vegetation.

9. Avoid silhouetting the aircraft when crossing ridgelines.

10. Know the terrain. Use recent photographic maps whenever possible.

It should be recognized that the terrain will not always provide an effective mask and at times detection must be expected. Mission planning should anticipate such detection and plan for the use of suppressive fires or other support measures (e.g., smoke, chaff, EW measures) to prevent acquisition and suppress enemy fire. The use of terrain flying techniques to counter the threat complicates the function of the

HC(A) and helicopterborne unit commander. The overview perspective of the objective area and the maneuver elements provided from the vantage points of altitude and independent operation is denied in a sophisticated threat environment. The following conditions shall be considered during mission planning.

Terrain masking will severely limit the capability of the HC(A) to communicate with controlling agencies during the execution of the mission.

If limited to line-of-sight communication (e.g., FM, VHF, UHF), the lowest frequency should be selected to achieve the most reliable communications. Although the HF radio is not limited to line-of-sight communications, it is not always reliable. Variations in both the ground and sky wave occur causing erratic operations.

The use of radio relay should be explored as an alternative solution. The use of detailed time schedules, control points, and phaselines to coordinate supporting elements rather than an on-call concept for coordination and execution can partially compensate for degraded communications.

The span of control will be limited by the ability to communicate with supporting and subordinate elements. Interflight/intraflight control will usually be limited to line-of-sight communications.

By constructing a terrain profile, it can be determined at what location along the route radio line of sight can be achieved, if at all. By predetermining these points, prearranged signals can be transmitted as the aircraft pass these positions.

The mission plan should be simple and in sufficient detail so that it can be executed without excessive reliance on communications. The use of communications should be reserved for directing the adoption of planned alternative courses of action, directing necessary modifications during mission execution, or coping with emergency situations.

6.4.2 Final Approach and Retirement. To enhance terrain masking techniques and ensure deception of the intended point of landing, four general approaches are used in the mission execution. Navigation must bring the mission aircraft to an exact point from which it will start its approach. Once the point has been reached, it will start one of the following approches (Figure 6-5).

1. 360° overhead
2. 180° offset
3. 90° turn-in
4. Straight-in.

During the final approach of the transport flight, the HC(A) or the attack helicopter flight must bring the required amount of fire power to bear on known or suspected enemy positions in and around the landing zone to protect the transport helicopters in their most vulnerable phase. This fire power will normally be delivered in and around the zone by the attack helicopters because they can accurately deliver ordnance in close proximity to the transport helicopters. Fixed-wing aircraft and other supporting arms, when required, will deliver ordnance in areas more removed from the landing zone during the landing phase.

When no known enemy positions exist in the area of the landing zone, the attack helicopter should consider delivering ordnance into an area where the enemy is most likely to employ his weapons.

Ordnance to be utilized in support of helicopter landings should be carefully selected with regard to fragmentation patterns and accuracy.

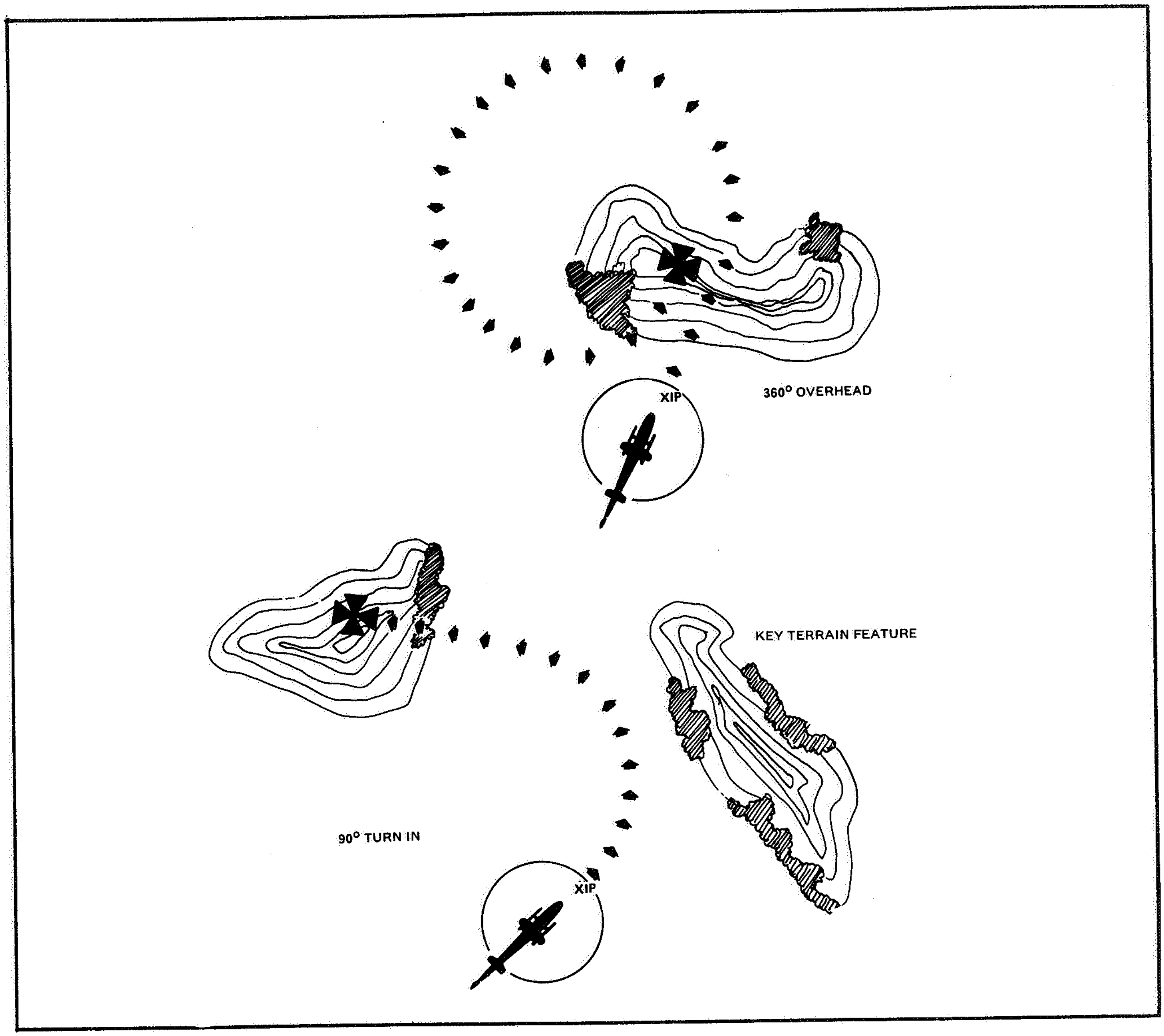

Figure 6-5. Final Approach to LZ (Sheet 1 of 2)

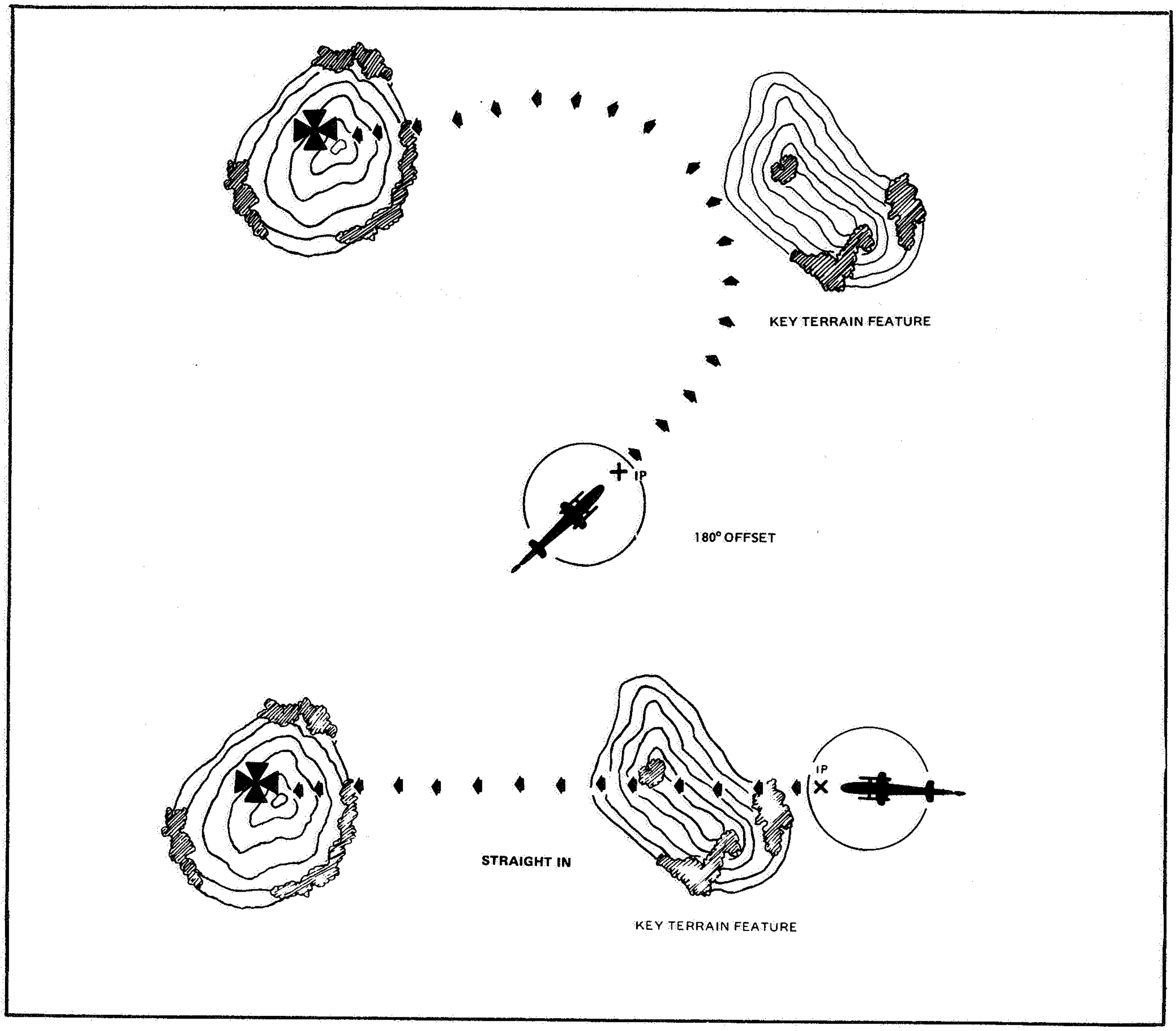

Figure 6-5. Final Approach to LZ (Sheet 2 of 2)

During the approach to a landing zone where enemy resistance is anticipated, the use of white phosphorus rockets or other masking agents should be considered to reduce the enemy's visibility and the accuracy of his fire. Care should be taken not to obscure the landing zone from the transport helicopters during their approach and landing.

If the transport helicopter receives hostile fire, the escort aircraft must react rapidly and bring the proper amount of suppressive fire to bear. The source of fire may be located by observing muzzle flashes, or it may be called by the transport helicopter or ground units using clock code/distance.

Note

> Actions to be taken by the transport helicopter when fire is taken should be prebriefed. Past experience has indicated that the dropping of a smoke grenade by the transport helicopter at the position where the fire was taken and clock code/distance may be effective.

When the transport helicopters are in the landing zone, the escort aircraft must maintain a constant lookout for enemy fire or movement that may endanger the transport helicopters. After the troops have disembarked, the attack helicopters must maneuver to be in a position to deliver suppressive fire as the transports lift out of the zone. The transport helicopters should be escorted until they are clear of all danger. The HC(A) and the attack helicopter pilot must be aware of all changes in the tactical situation during all phases of troop assaults. They should analyze all information and constantly look for methods of improving their tactical advantage including changing the final direction of approach, patterns to be flown by the attack helicopters, employment of supporting arms, or changing the landing zone. When it is decided that a change is to be made, all units participating in the troop assault must be advised (Figures 6-6 and 6-7).

6.5 TACTICAL FORMATIONS

6.5.1 Escort Techniques in a Sophisticated Threat Environment. In a sophisticated threat environment, the formation used en route is dictated by METT. Regardless of the specific formation, the helicopters will be staggered and the distance between them will vary according to the terrain being crossed. Each aircrew in the flight is responsible for the accuracy of navigation and must be prepared to take the lead at any time and proceed to the destination. Light signals and code words should be used to assist in reducing radio communications, in the event of lost communications or radio jamming by the enemy.

When terrain flying, larger numbers of helicopters facilitate detection. In addition, a large group requires more terrain relief to remain masked than does a small group. When large groups of helicopters are required to accomplish the mission, dispersion can be achieved by using numerous routes into an area with small groups of helicopters utilizing each route. However, it will often be necessary to use a single route in order to concentrate limited suppressive fires.

When moving, a small element of two or three helicopters should normally maintain its integrity so as to return an adequate volume of fire if attacked. Units should employ traveling, traveling overwatch, and bounding overwatch techniques. When flying nap-of-the-Earth, individual aircraft move as individual infantryman in a squad. The squad leader picks the general direction of travel but each infantryman picks his terrain and moves by rushes or bounds within the loose formation. He is not required to step in the footprints of every man ahead of him. With helicopter formations, following helicopters pick their own terrain, moving by bounds independently from point to point within the formation. The pilot must be particularly careful not to maintain standard distances from preceding helicopters or exact flight routes which can aid enemy

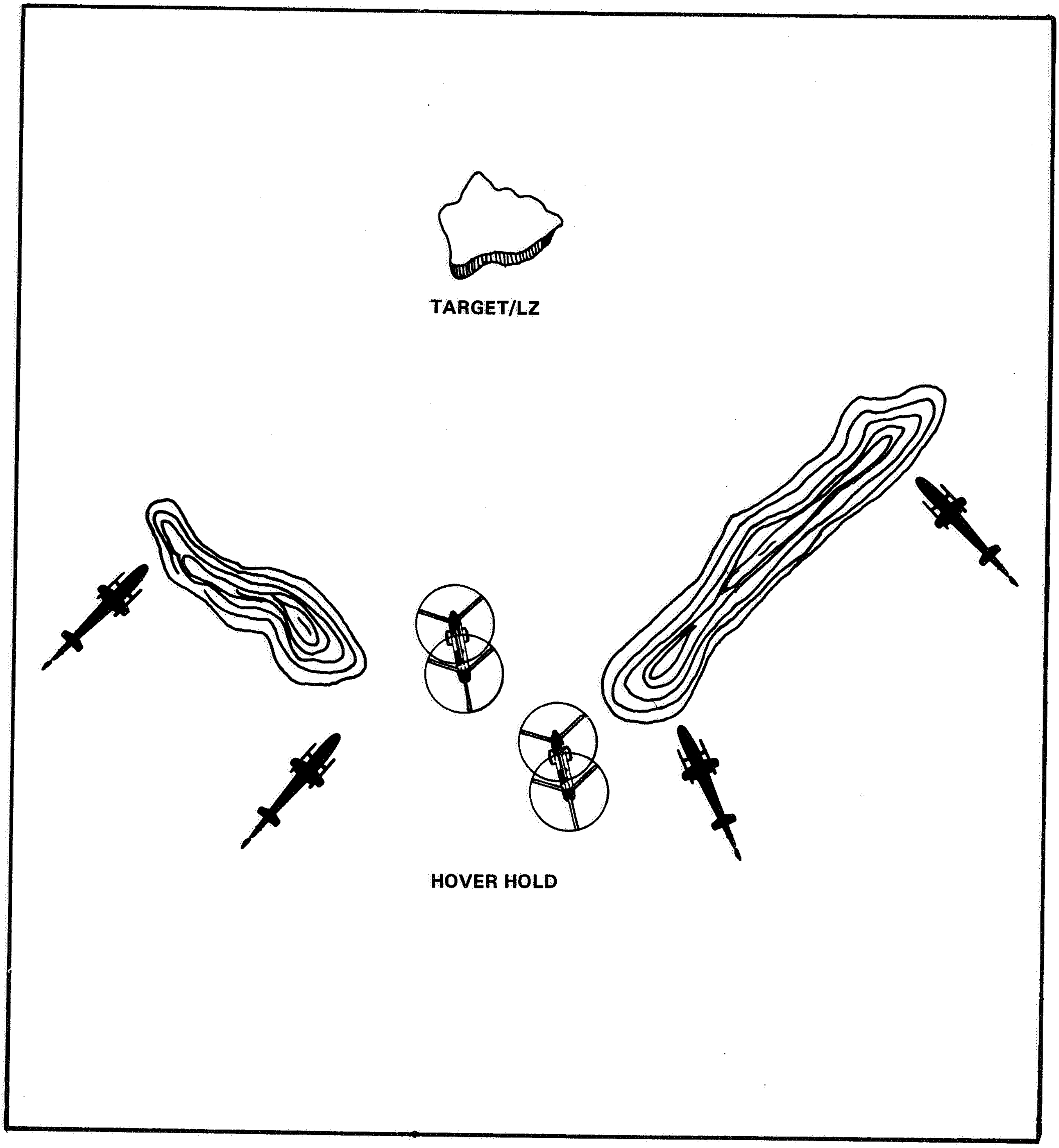

Figure 6-6. Sophisticated Threat LZ Cover Pattern

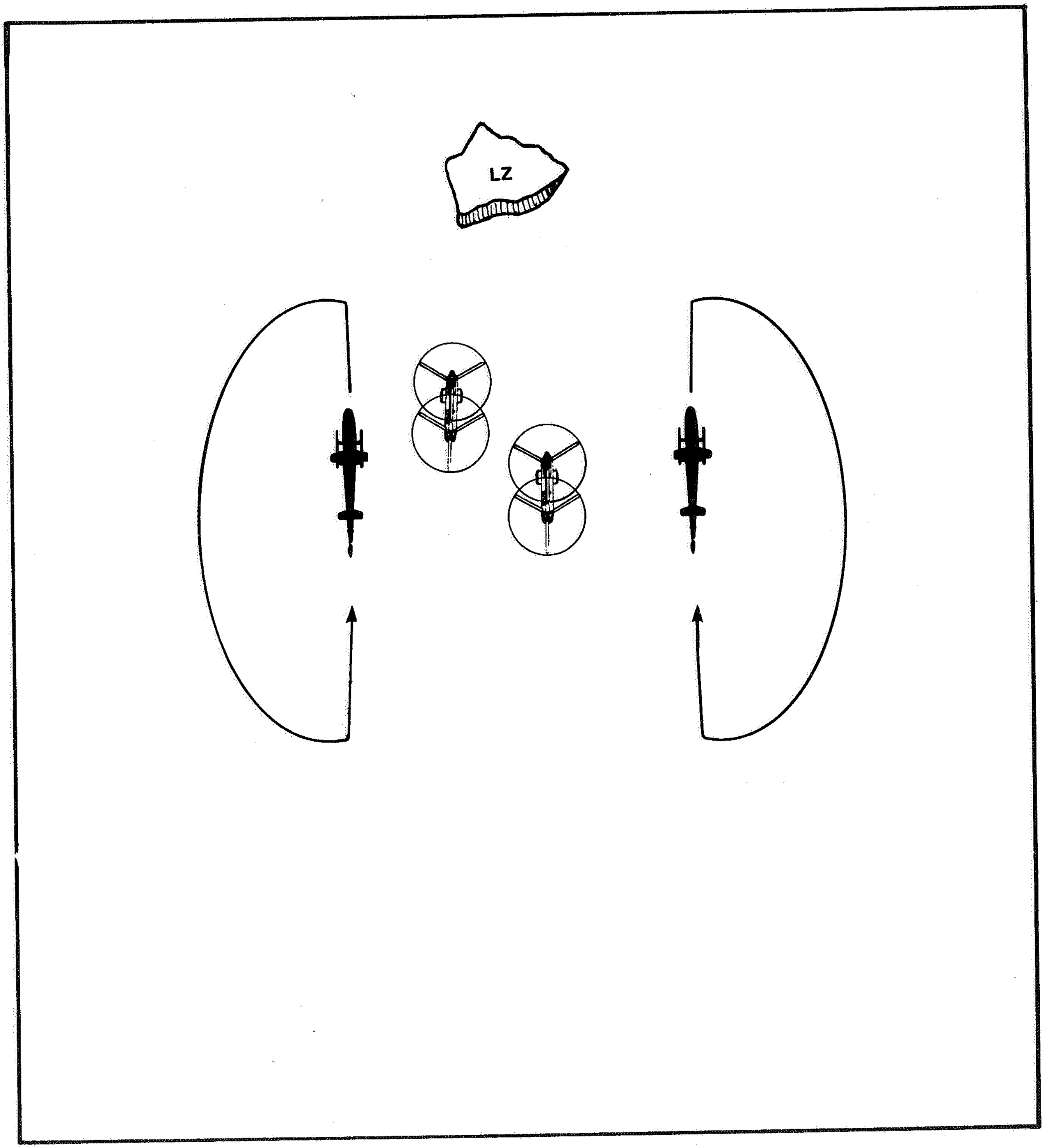

Figure 6-7. Butterfly LZ Cover Pattern

gunners. Each pilot must be aware of the situation, the terrain, and the mission. He must not blindly follow the tailpipe of the helicopter ahead.

Traveling, a NOE technique, is used when contact with the enemy is not likely and speed is important. The flight moves on a column axis with interval between aircraft based on visibility, terrain, and tactical considerations. The primary orientation of the flight is forward during escort operations with the general direction of the flight being established by the lead aircraft. Movement of the flight should be as constant as the terrain will allow. Trail aircraft may move in parallel columns to shorten the column and decrease reaction time within sections; aircraft are dispersed to the degree that will eliminate temporary pinching together of the flight, but normal interval is reestablished as soon as possible (Figure 6-8).

The overwatch position is a key element in NOE operations. It offers the advantages usually associated with a defensive ground position, but without the loss of initiative. These include:

1. Protection offered by covered and concealed positions

2. Good observation and fields of fire

3. Immediate and controlled reaction to any threat

4. Early warning of an enemy ground threat.

Traveling overwatch is used when the likelihood of enemy contact is possible. Precautionary measures are justified, but speed is desirable. It is also characterized by continuous movement of the main element. In the escort role, the forward section of AH-1s, the overwatch element, move from covered position to covered position, making maximum use of the terrain and vegetation. The movement is keyed to that of the lead overwatch element, but the desired visual and weapons coverage surrounds the main element of transports which may be using traveling techniques. This is accomplished by increasing overwatch aircraft separation from the main element of transports. The distance should be sufficient both laterally and in depth to prevent interruption of the main element momentum should fire be received by any aircraft in the overwatch element. Individual aircraft within the flight should use the terrain to reduce exposure. Therefore, this is not a fixed formation as the actual positioning of helicopters and distances between them will vary considerably based on terrain, visibility, supportability, and other tactical considerations.

Bounding overwatch is an NOE technique used when enemy contact is imminent and speed is not of the essence. The escort aircraft covers the progress of the bounding transport flight from a vantage point that allows for observation and fields of fire against potential enemy positions. This requires an understanding of the factors affecting employment of enemy weapons systems. Individual aircraft move from covered position to covered position only after their respective wingman has established a covering position where he can immediately support the bounding aircraft. Movement is slow and deliberate. The escort aircraft should find the enemy first and take the appropriate action. The length of each bound is closely tied to terrain and the range of the overwatch element's weapons.

6.6 ESCORT CONSIDERATIONS IN A HOSTILE AIR ENVIRONMENT

One primary consideration supersedes all others in the escort role: the attack helicopter's mission is to protect the transports. In most environments, the attacker will acquire the transports long before he sees any of the attack helicopters. Because of this, a great deal of the Cobra pilot's attention should be focused on the flanks and 6 o'clock position of the transports. The pilot at the controls looks inboard and through the flight. The pilot not at the controls has outboard lookout responsibility. During any engagement, the *two versus two* guidelines apply. The transports will be executing their breaks while the attack helicopters position themselves to prevent a penetration of the formation. It is too late to think of all contingencies 5 minutes before takeoff. Several guidelines should be employed long before flight into a hostile air environment.

1. Both transport and attack helicopter crews should have experience in *two versus two* maneuvering in joint missions in a hostile air environment.

2. Joint planning and briefings are mandatory.

3. Plan for and use fixed-wing cover.

4. Use terrain to mask the flight.

5. Use well-dispersed formations.

6. Use slower airspeeds; masking is easier and shadow/airframe movement from altitude is less noticeable.

7. Use standard lookout doctrine.

8. Be constantly aware of the flight's 6 o'clock.

9. Attack helicopters avoid flying in the flight's 6 o'clock position.

10. Keep evasive break radio calls short and concise. To avoid confusion, preface these calls with the flight's identifier (i.e. "ADAM, BREAK RIGHT, BOGEY RIGHT 2 O'CLOCK").

11. Have a *scatter* plan with appropriate rendezvous points.

12. Attack helicopters are responsible for safe separation.

Once a flight has been attacked, the primary consideration is to disengage with

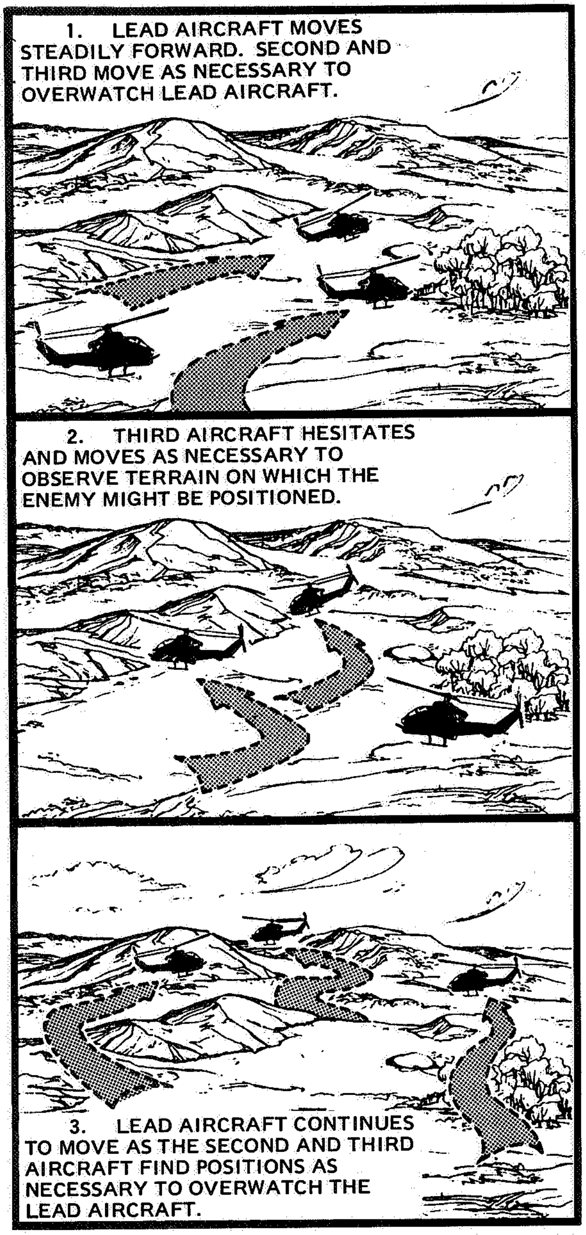
1. LEAD AIRCRAFT MOVES STEADILY FORWARD. SECOND AND THIRD MOVE AS NECESSARY TO OVERWATCH LEAD AIRCRAFT.
2. THIRD AIRCRAFT HESITATES AND MOVES AS NECESSARY TO OBSERVE TERRAIN ON WHICH THE ENEMY MIGHT BE POSITIONED.
3. LEAD AIRCRAFT CONTINUES TO MOVE AS THE SECOND AND THIRD AIRCRAFT FIND POSITIONS AS NECESSARY TO OVERWATCH THE LEAD AIRCRAFT.

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Figure 6-8. Traveling Overwatch

minimum losses. It is imperative that all aircrews understand this and the procedures to be used to effect this engagement. After the initial evasive break, the transports should scatter into the terrain. Rendezvous at prebriefed points should then be executed. As the transports execute their breaks, the Cobras should move to engage the attackers. If practical, half of the escort aircraft will shadow the transport flight as it completes the rendezvous. The remaining escort aircraft will occupy the attacking fixed wing until the flight has dispersed. At this point, they will effect a disengagement. This situation is much more critical when the flight is attacked in a large open area. Success depends on the individual pilot's skills in the flight. At the completion of evasive breaks, the flight should remain well dispersed but should continue on course. Some key points to remember are:

1. Call for the fixed-wing cover immediately upon sighting enemy aircraft.

Note

> It is important to have a simple prebriefed method by which the friendly fixed wing can locate or keep track of the helicopter flight. Coded en route checkpoints with the en route timing works well.

2. Attack helicopters must fight to protect the flight and attempt to disengage after transport aircraft are clear.

CHAPTER 7

Fire Support in a Sophisticated Threat Environment

7.1 CLOSE-IN FIRE SUPPORT

Performing close-in fire support in a terrain flight profile is difficult. While in close proximity to friendly troops extreme care must be exercised to avoid injuring the supported troops. Figure 7-1 shows the long and narrow beaten zone for the 2.75-inch FFAR when delivered from terrain flight. Positioning of the firing aircraft must be such that the long axis is parallel or directed away from friendly troops.

The beaten zones for hover and running fire are approximately the same at near ranges (less than 3,000 meters), but at longer ranges the beaten zone for running fire is smaller than for hover fire. Figure 7-1 compares the length of the beaten zone as a function of range for hover and running fire.

The size of the beaten zone increases and the range achieved decreases when the quantity of rockets fired in a single salvo increases from four pairs to seven pairs of rockets. The size of the beaten zone is also affected by the rate of fire (milliseconds). High rates of fire allow the rockets to leave the rocket launcher closer together, thus decreasing the size of the beaten zone.

7.2 TERRAIN FLIGHT DELIVERIES

During terrain flight profiles, the three basic types of delivery are running fire, hovering fire, and pop-up fire.

7.2.1 Running Fire. Running fire is fire delivered when the helicopter is in translational lift. Direct and indirect fires can be delivered during running fire. The forward airspeed adds stability to the helicopter, thus increasing the delivery accuracy of the weapons system. This type of fire can be performed at terrain flight altitudes making the aircraft less vulnerable to enemy air defenses than diving fire.

7.2.2 Hovering Fire. Hovering fire is fire delivered when the helicopter is below translational lift. It may be stationary or moving, but movement is always below translational lift airspeed. Because the trajectory of the projectile is not significantly changed, this chapter does not differentiate between the two conditions of hover flight. Hovering fire is performed after unmasking from a defilade position. Indirect hover fire may be delivered from firing points obscured from the enemy by terrain features. The hover firing position is maintained for only short periods of time. Following ordnance delivery, the helicopter should remask. Where terrain permits, the helicopter should also be moved laterally between ordnance deliveries so that it does not reappear to the enemy from the same position. Because the helicopter is less stable at a hover, the accuracy of the weapons system is reduced. Point-type weapons, such as tow are the most effective weapons when firing from a hover.

7.2.3 Pop-Up Fire. Pop-up fire is a modification of running and diving fire in which the aircraft does a slight climb to enable a shallow dive angle attack. The primary advantage of pop-up fire is the increase in accuracy attainable with diving fire.

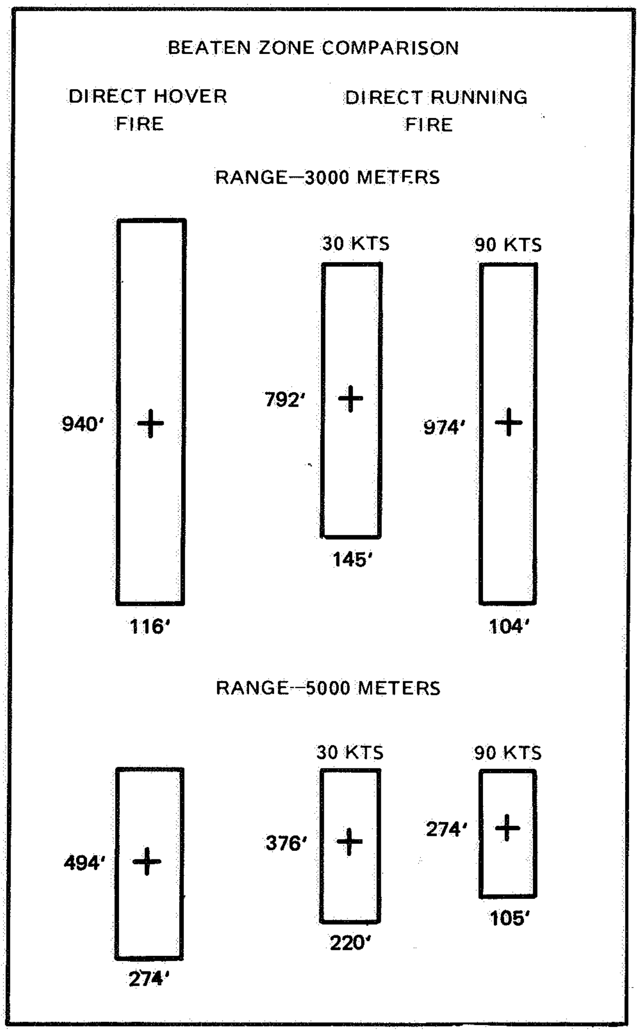


Figure 7-1. Beaten Zone Comparison

7.3 MISSION TYPES

7.3.1 Targets of Opportunity. The flexibility of the attack helicopter permits rapid deployment throughout the battlefield. Because the attack helicopter can be employed rapidly, aircrews will not always have the opportunity to plan a mission in detail. For example, a flight of attack helicopters may be waiting in the holding area when an observer acquires a target. Upon receipt of a mission, the flight is ready for takeoff. To compensate for the lack of time to plan for the mission, multiple preplanned attack routes should be selected. Other planning factors such as preflighting the helicopter and map reconnaissances can be performed while waiting for a mission.

7.3.2 Immediate Reaction. During the conduct of a mission, whether it is a preplanned mission or a target of opportunity, an aircrew may encounter a target or a threat weapon which requires immediate action to gain a tactical advantage. The nature of the target may be that it is of higher priority than that which the attack helicopter is en route to engage. If it is a threat weapon (e.g., tactical aircraft, air defense gun, or missile), the situation would require that it be destroyed or evaded in order to continue the mission. In either situation, failure to initiate immediate action by the aircrew will give the enemy the advantage. The decision is a judgment made by the aircrew based upon the priority of the target and threat encountered. Action initiated by the aircrew must be reported when the tactical situation permits.

7.3.3 Defense. During the conduct of an offensive operation, the attack helicopter aircrew must move about the battlefield in search of targets, over unfamiliar terrain, while subject to detection and engagement by enemy threat weapons. When employed in the defense, aircrews can move over familiar terrain into attack positions and engage targets from firing points that provide the best cover and concealment. In the defense, the possibility of being engaged by enemy air defense weaponry or tactical air is minimized. Prior to actually engaging the enemy, the force commander will have planned the defensive positions for the unit. Primary and alternate attack positions will be designated for the attack and select attack routes into and out of the area and individual firing points. The considerations for selecting attack routes, attack positions, and firing points are the same as discussed for offensive operations. After the firing points are selected, each aircrew should develop a range card. The purpose of the range card is to determine if there are areas within the field of fire of each firing position where the enemy cannot be engaged. The lateral coverage includes an area approximately 30° in width at the minimum range. As the gunner views the area within his assigned field of fire, he notes the heading, the distance, and the width of the obscuration. With this information, the gunner draws a range card for his firing point. After each aircrew has drawn a range card, the flight leader will consolidate the cards. By displaying the range cards on the map, areas within the unit's field of fire where enemy targets cannot be engaged can be determined. If the desired overlap is not achieved or areas exist where the enemy cannot be engaged, individual firing points should be adjusted.

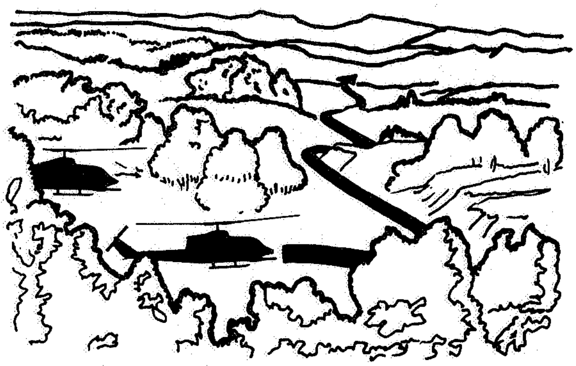
7.4 AERIAL FIRE SUPPORT

When selecting a route, the aircrew is actually planning detection avoidance and must make maximum use of the principle of cover and concealment. To do this, the aircrew must know the local enemy threat and how he has been employing his air defense weapons systems. Routes can then be planned to keep the highest possible terrain and/or thickest vegetation between the enemy and helicopter. To do this in mountainous or rolling terrain, plan the route on the friendly side and below the crest of a ridgeline. In very gently rolling terrain, plan the route across the low terrain, such as streambeds, where it does not serve as an avenue of approach to the enemy position. In arid or open areas, plan the route along streambeds or depressions where trees may exist. When feasible, routes should avoid population concentrations because of the large number of hazards. Routes should not follow manmade linear features such as roads, canals, or pipelines unless required because of restricted visibility. These linear features normally do not follow a course which offers the greatest masking opportunity. To the maximum extent possible, routes should be planned over heavily vegetated areas as opposed to open terrain. This is especially true near enemy positions because the vegetation further restricts the ability of the enemy to detect the helicopter. By flying over vegetation, the helicopter's shadow, which is primary means by which high-performance aircraft visually locate low-flying helicopters, can be broken and lost in the darker vegetation. Because helicopters are susceptible to radar or visual detection on the side of a slope facing the enemy regardless of altitude, ridgelines should be crossed at low points as rapidly as possible to reduce exposure time and to avoid silhouetting the helicopter. Plan primary and alternate routes into and out of the objective area (Figures 7-2 through 7-4).

Checkpoints used along a route should be terrain features in preference to manmade objects. This is because manmade features are subject to change or destruction, and unplotted features may be confused for intended checkpoints. When manmade objects are used, they should be used primarily to help confirm the identity of terrain features.

Specific altitude restrictions should be determined for each route. When operating within range of enemy air defense weapons, maximum altitude is determined based on the masking offered by available terrain and vegetation. When operating beyond the range of enemy air defense weapons but within range of enemy surveillance equipment, altitude is determined based on friendly tactical considerations such as airspace management for aircraft, artillery, and air defense weapons. Friendly tactical considerations also include counterintelligence considerations. For example, altitude should be below enemy surveillance capability in the vicinity of command posts (CP), assembly areas, and forward-area rearm and refuel points to prevent enemy radar from locating these positions because of the high density of traffic.

Even when using NOE flight, there will be times when detection must be expected. This



ROUTE PLANNING CAN ONLY BE AS GOOD AS THE MAP IS ACCURATE. IN SOME CASES, WE MAY BE WORKING WITH AN OUT-OF-DATE MAP OR MAPS ON WHICH THE CONTOUR INTERVAL IS TOO LARGE TO SHOW TERRAIN RELIEF ADEQUATELY; THEREFORE, CHANGES TO THE ROUTE, BASED ON OBSERVATION OF THE ACTUAL TERRAIN, SHOULD BE MADE IF NECESSARY TO REMAIN MASKED.

Figure 7-2. Route Planning

dictates that planning also provide for suppressive fires (artillery, high-performance aircraft, and naval gunfire), smoke, chaff, standoff jamming, or any other means available that can prevent the enemy from locating/attacking the helicopter. Whenever operating inside or near the range of enemy air defense weapons/artillery, the need for suppressive fires should be considered and, if necessary, requested by the aircrew (Figure 7-5).

7.5 HOLDING AREAS (HA)

Holding areas are occupied by attack helicopters during the time that FACs or FAC(A)s are searching for targets. The area should be well forward, but it must provide cover and concealment from enemy observation and antiaircraft fires. It must also be large enough to provide for dispersion if within range of enemy artillery. The holding area should not be on or near a prominent terrain or manmade feature that might be an enemy preplanned artillery target. Ideally, it should also be sufficiently vegetated to provide some protection from aerial observation. These considerations are especially important if helicopters will be shut down in the holding area. Since the holding area is well forward, it may be necessary to supplement its security by insertng a small infantry unit prior to landing the attack helicopters. Aerial reconnaissance of the surroundings area may be necessary while occupying the holding area. When the unit's mission is to attack targets of opportunity, the initial coordination between the FAC/FAC(A) and attack elements normally is made in the holding area. Prior to departing the holding area, each aircrew should know the location of the attack positions, its target, sector of fire, and other essential command and control information (Figure 7-6).

7.6 ATTACK ROUTES

The attack route is the corridor used by the flight to move from the holding area to the attack position. An ideal attack route is one

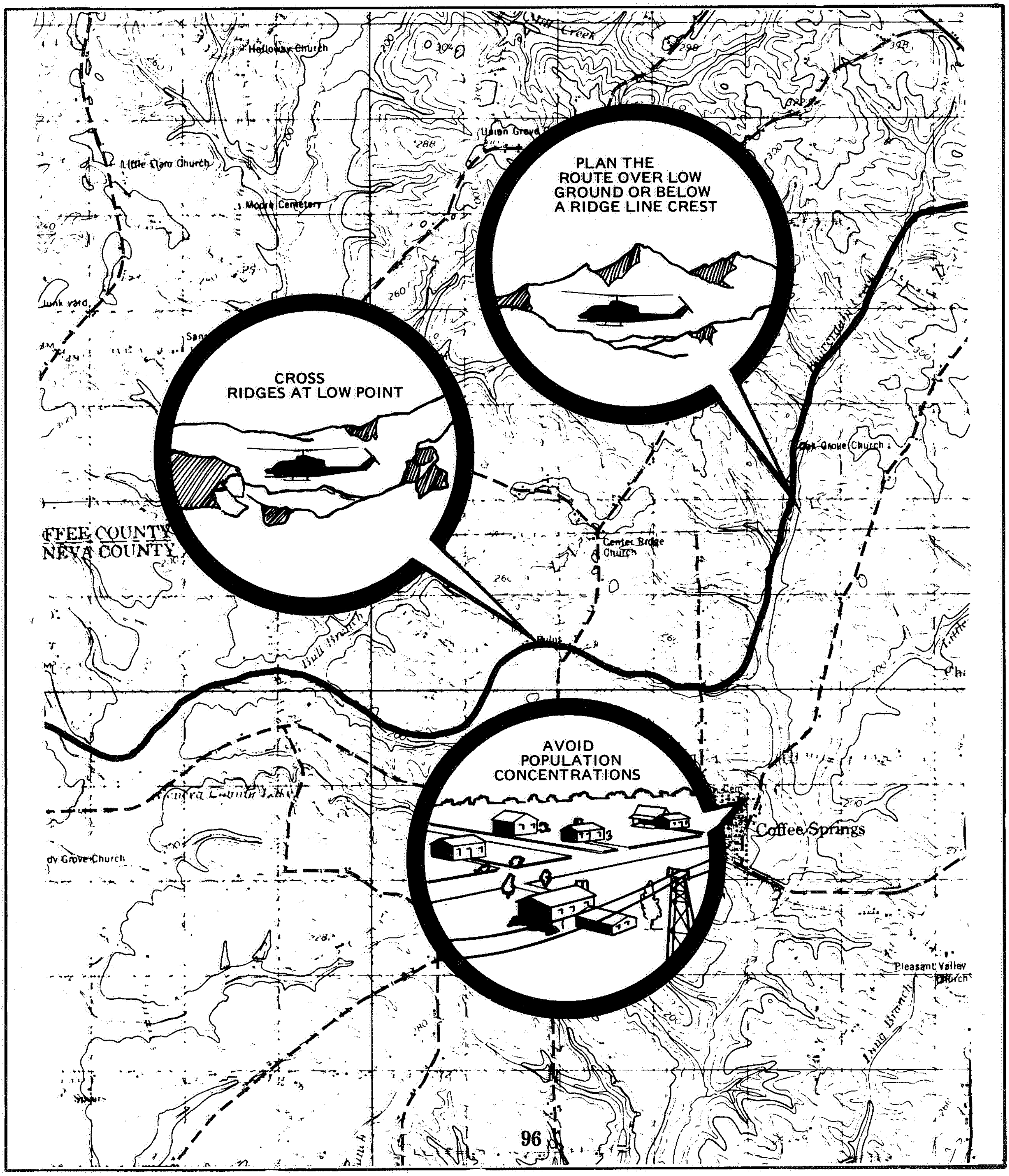


Figure 7–3. Avoid Visual or Radar Contact

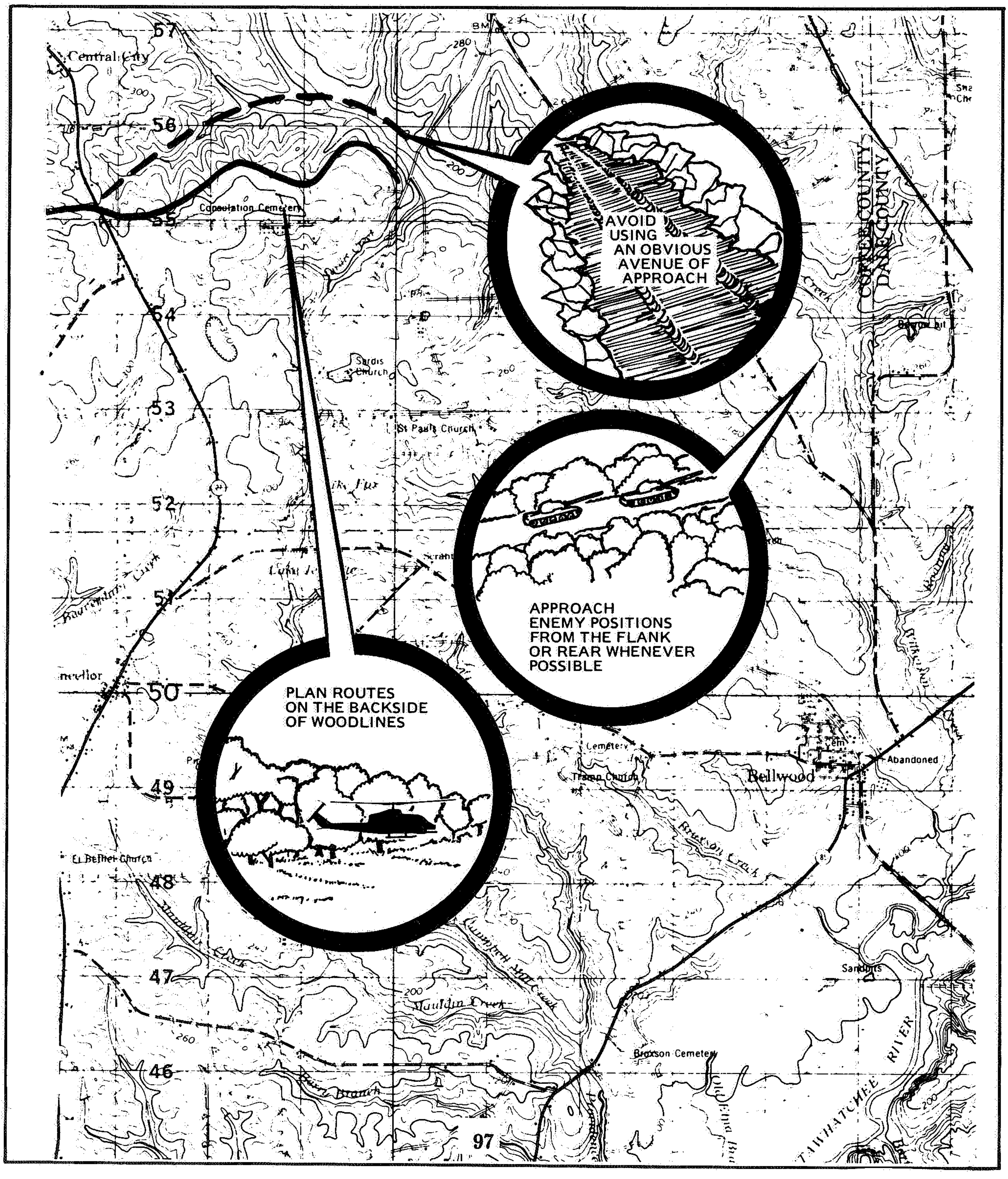


Figure 7-4. Route Planning With Maximum Cover

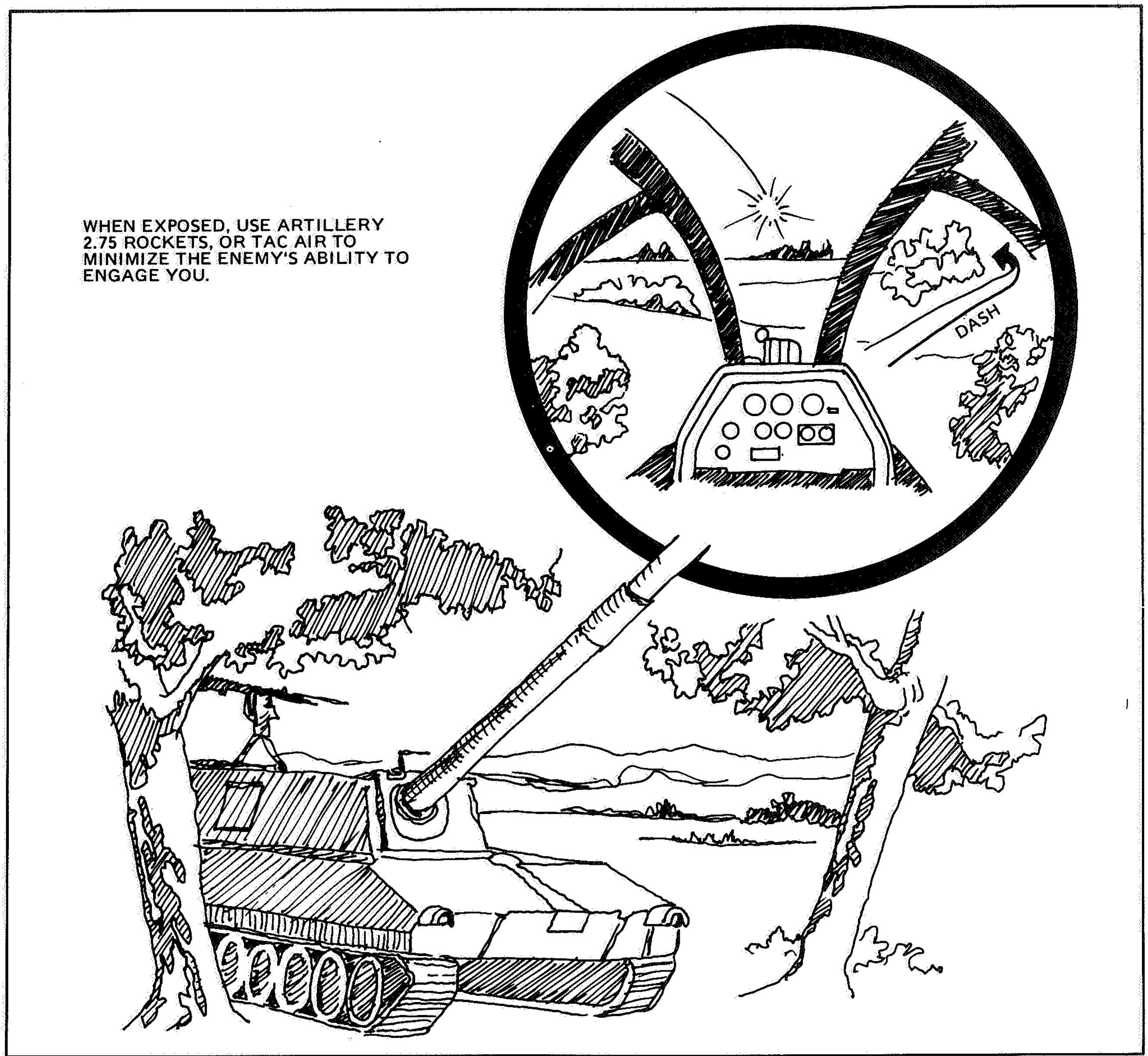

WHEN EXPOSED, USE ARTILLERY 2.75 ROCKETS, OR TAC AIR TO MINIMIZE THE ENEMY'S ABILITY TO ENGAGE YOU.
DASH

Figure 7-5. Need for Suppressive Fires

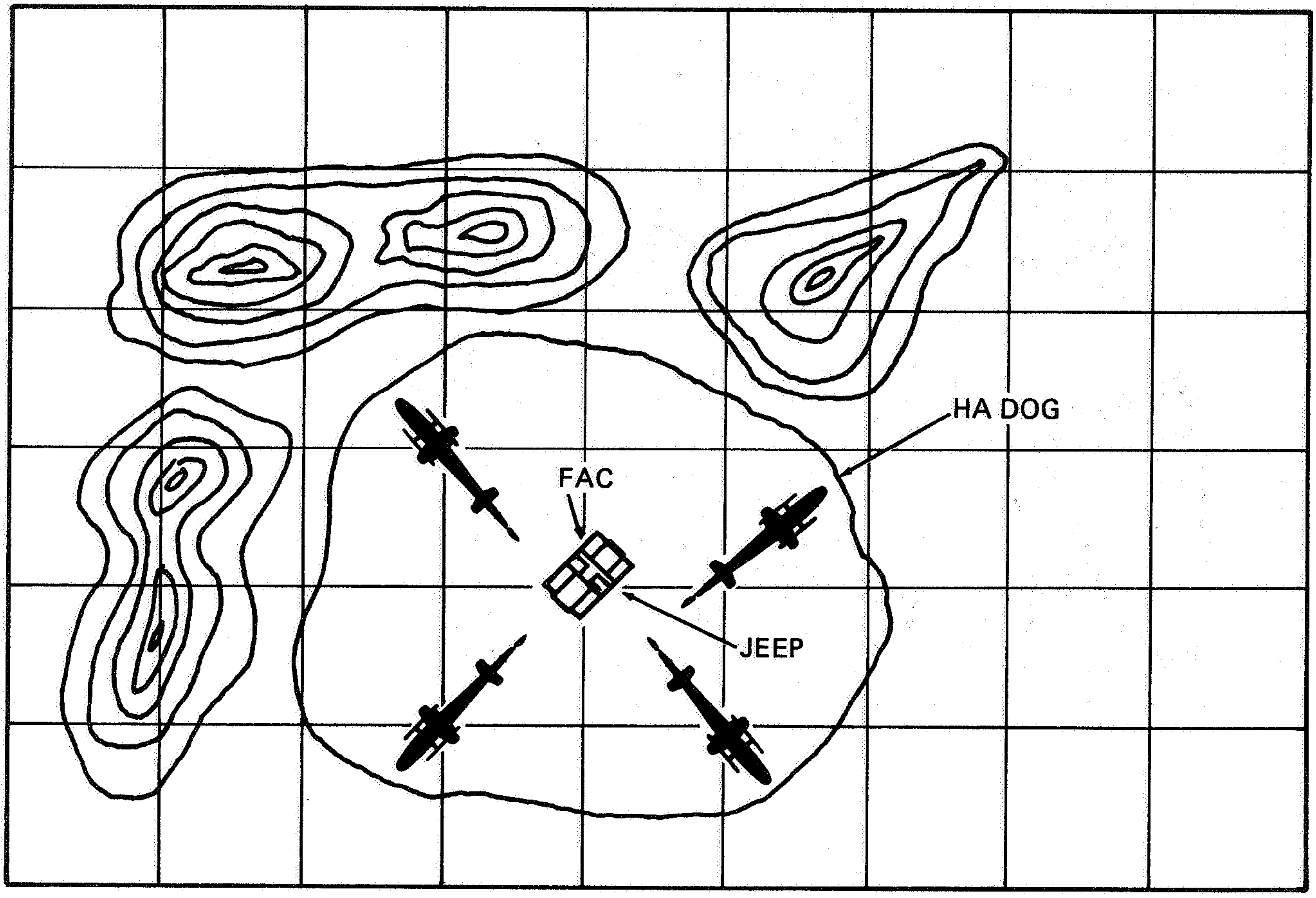


Figure 7-6. Holding Areas

that allows the unit to move into the attack position undetected. When the tactical situation dictates NOE flight to the attack position and visual contact with the preceding helicopters cannot be maintained, individual aircrews may have to navigate to the attack position. Detection, even if beyond the range of enemy air defense weapons, eliminates the attack helicopter's advantage of surprise. Therefore, if detection is possible, smoke, chaff, rockets, and artillery should be used to mask the unit's movement. The specific considerations relating to route selection as discussed previously generally apply to attack routes (Figure 7-7).

7.7 ATTACK POSITIONS (AP)

The attack position is a maneuvering area which contains firing points, laterally and in depth, for the flight. The attack helicopter crews maneuver within the attack position,

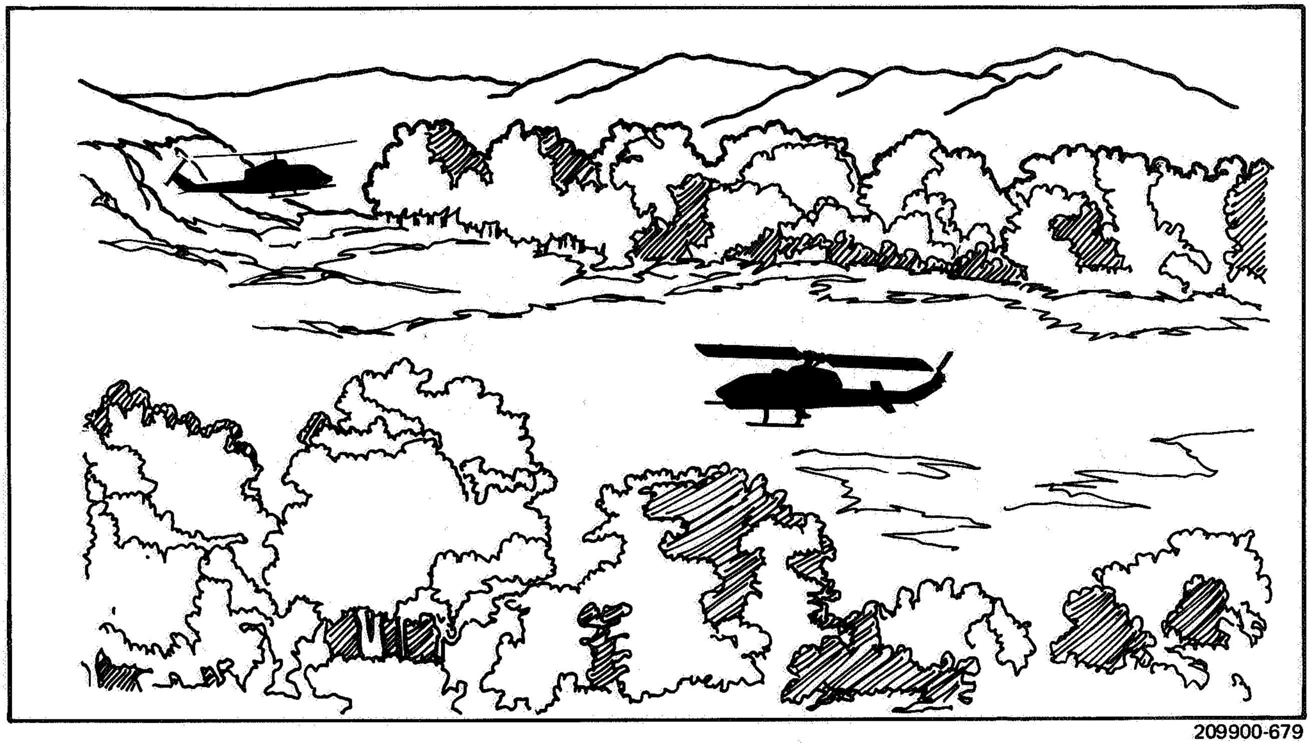


Figure 7-7. Attack Routes

select firing points for their individual aircraft and remain masked, while awaiting the time to target (TTT) or time on target (TOT). To prevent their detection and engagement, the amount of time spent maneuvering within the attack position should be held to a minimum. The process of selecting attack positions begins during premission planning. Aircrews should conduct detailed map reconnaissance of the entire area of operations to identify tentative attack positions and alternates, as well as holding areas and attack routes. The suitability of these areas can later be confirmed or modified by aerial reconnnaissance as tactical requirements dictate (Figure 7-8). During the selection process, emphasis should be placed on cover and concealment. The terrain and vegetation leading to and surrounding the attack position must conceal the attack helicopters from observation by the enemy. For this reason, the map reconnaissance should concentrate on locating attack positions based upon the following:

1. Terrain relief

2. Access routes

3. Availability of alternate positions.

During the aerial reconnaissance, the above factors will be confirmed, and actual attack positions will be selected after considering the following:

1. Range to the target

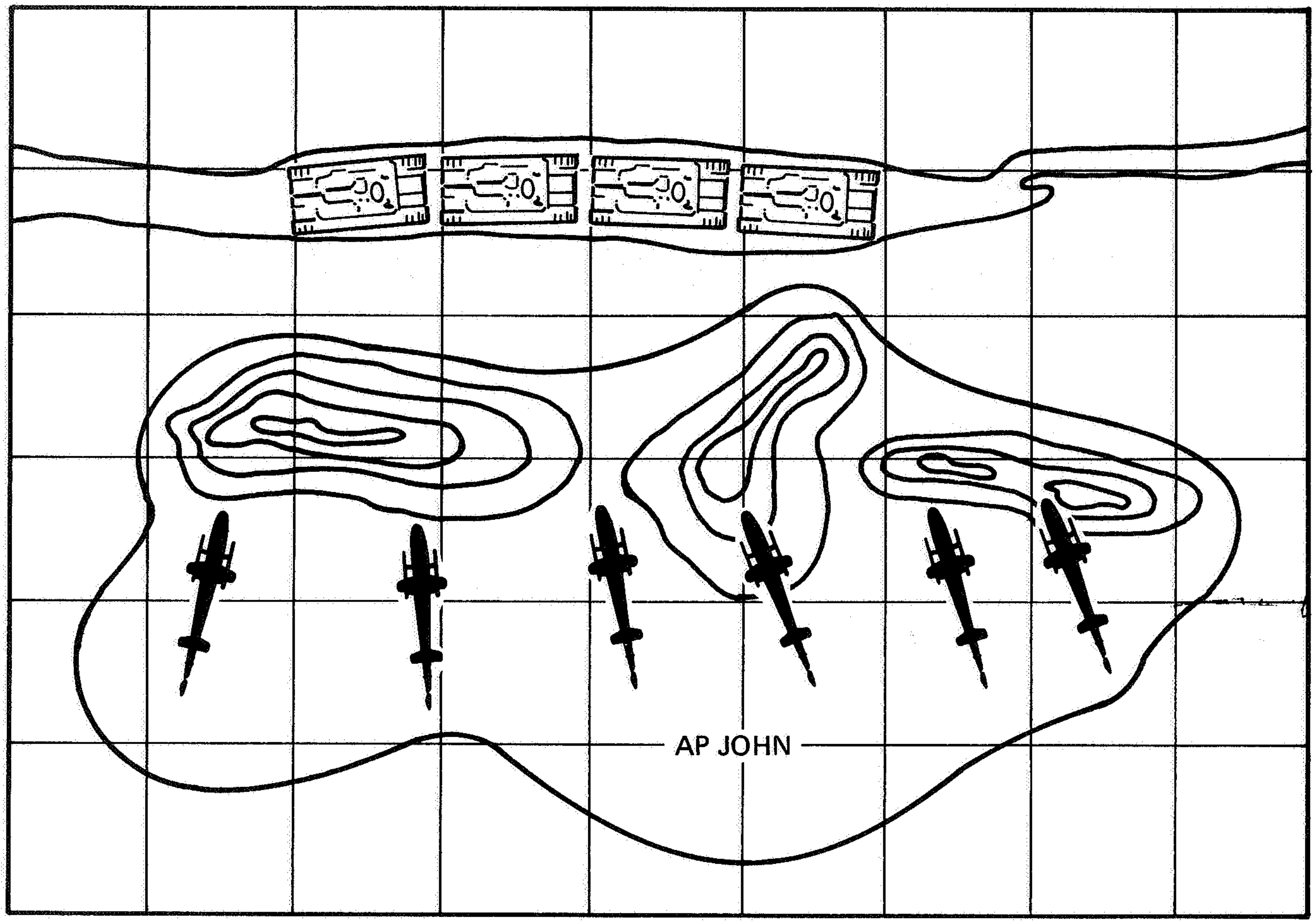


Figure 7-8. Attack Positions

2. Nature of the target

3. The potential effects of rotorwash on surrounding terrain

4. Adequate area for proper dispersion between helicopters with multiple firing points.

5. Obstacle clearance; e.g., wires.

Ideal attack positions will provide cover for the attack helicopters to prevent detection by enemy radars and engagement by enemy air defense weapons. They will provide concealment from visual observation. An attack helicopter can be easily detected even though it isn't seen if the enemy can observe unusual movement of the trees, dust clouds, or blowing debris caused by rotorwash (Figure 7-9).

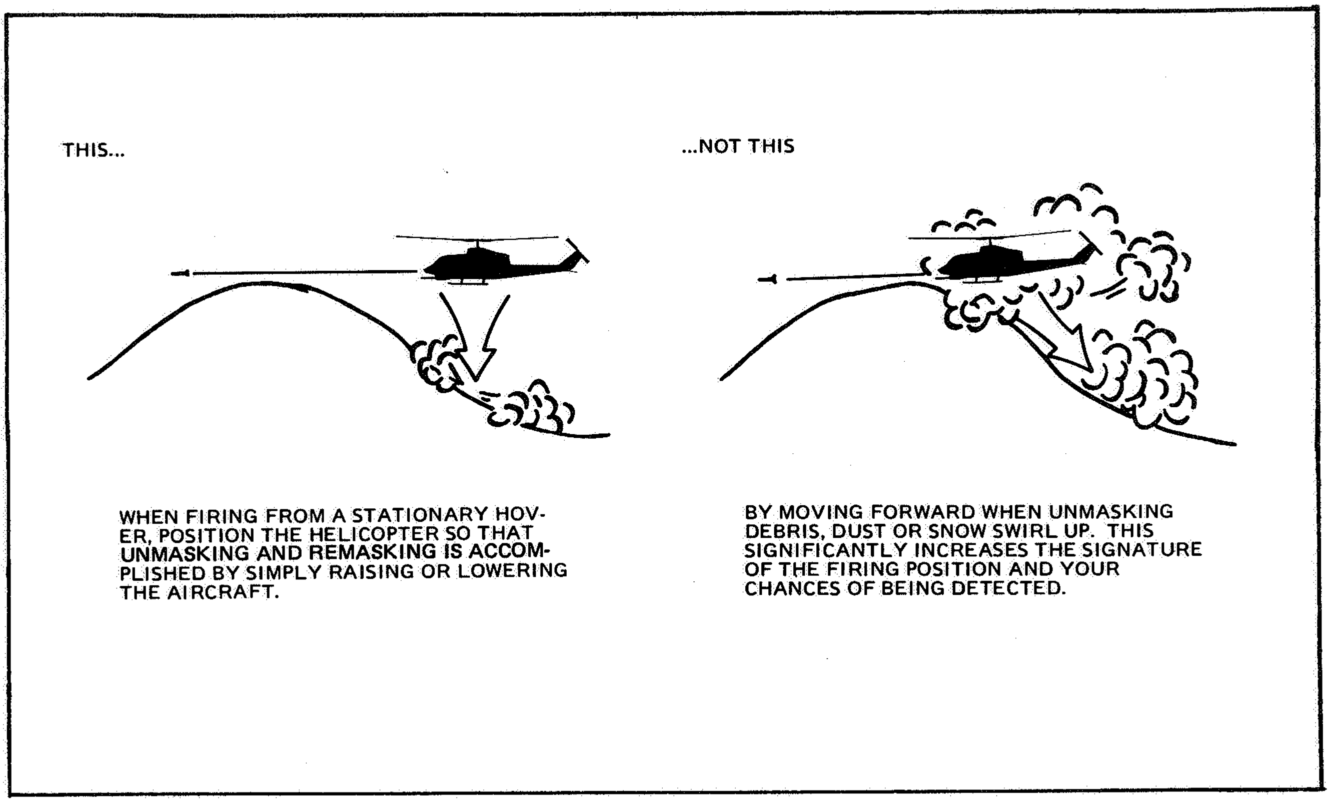

THIS...
...NOT THIS
WHEN FIRING FROM A STATIONARY HOVER, POSITION THE HELICOPTER SO THAT UNMASKING AND REMASKING IS ACCOMPLISHED BY SIMPLY RAISING OR LOWERING THE AIRCRAFT.
BY MOVING FORWARD WHEN UNMASKING DEBRIS, DUST OR SNOW SWIRL UP. THIS SIGNIFICANTLY INCREASES THE SIGNATURE OF THE FIRING POSITION AND YOUR CHANCES OF BEING DETECTED.

Figure 7-9. Firing Points

For night operations, the enemy's visual acquisition capabilities are greatly reduced. Therefore, the primary consideration is to mask the helicopter from electronic acquisition. When this is not possible, aircrews should keep a terrain feature behind the helicopter. These techniques may either block the helicopter from electronic view or place the helicopter among ground clutter so as to degrade the enemy's radar.

Attack positions are occupied and vacated on order of the flight leader. Aircrews are allowed freedom of movement within the flight's attack position unless restricted by the flight leader. The flight leader may reassign attack positions based on the size of the unit. For example, if a large flight is conducting an attack, the flight leader will normally break the flight's area into section attack positions. The section leader may further designate individual firing points within the section's attack area.

7.8 FIRING POINT (FP)

A firing point is a specific point within the attack position which is occupied by a single attack helicopter while actually engaging targets. The selection of a firing point should be based on the following considerations:

1. Range — the firing point should be located so that the kill zone is within the effective range of the ordnance being deployed.

2. Field of fire — the firing point should permit visibility of the targets throughout the kill zone.

3. Target altitude — the firing point should be equal to or at a higher elevation than the target area.

4. Background — terrain features (vegetation, hills) should be located behind the firing point so that the helicopter will not be silhouetted.

5. Shadow — when possible, the firing point should be within an area covered by a shadow.

6. Sun — the firing point should be located so that the sun is positioned behind or to the side of the helicopter.

7. Rotorwash — a firing point should be located so that the effect of rotorwash on surrounding terrain (e.g., wires, debris, leaves, snow, dirt) is minimized.

8. Adequate maneuver area — the area surrounding the firing point should permit ease of maneuver to and from the firing point.

9. Concealment — vegetation surrounding the firing point should facilitate concealing the helicopter.

10. Flight visibility — the firing point should permit visibility with other members of the flight.

Within the flight's attack position, firing points may be designated for each helicopter by the flight leader based on recommendations by the FAC/FAC(A), or the flight leader may designate sectors of fire for each helicopter and leave final selection of firing point up to each aircrew. Alternate firing points will be tentatively selected by the FAC/FAC(A)/flight leader for continuing the attack once the attack is in progress.

When the targets close within range (or TOT), the attack helicopters will unmask from the firing point, acquire their targets, and begin firing (Figure 7-10).

Aircrews will engage all targets within their individual sectors with the highest priority being assigned to enemy air defense weapons. Once the attack has begun, targets that are the greatest distance from cover should be engaged first. This procedure will allow engagement of that target before it can reach cover. Firing is conducted from an altitude just above the terrain mask. The attack helicopters will remain in their attack positions and continue to fire until:

1. The enemy has been destroyed.

2. Ammunition has been expended.

3. The attack position becomes untenable.

4. The flight leader directs that the attack be terminated or that alternate positions be occupied.

5. The flight is relieved on station by a new firing unit.

In the event an aircrew must vacate its firing point and move to an alternate, the aircrew should remask and remain masked until in position to resume the attack. Enemy air defense weapons and supporting artillery will make every effort to fix the location of the attack helicopters and can be expected to return fire in mass and volume. After the attack has been initiated, the aircrews must be prepared to move to alternate positions and have appropriate routes and coordination measures preplanned.

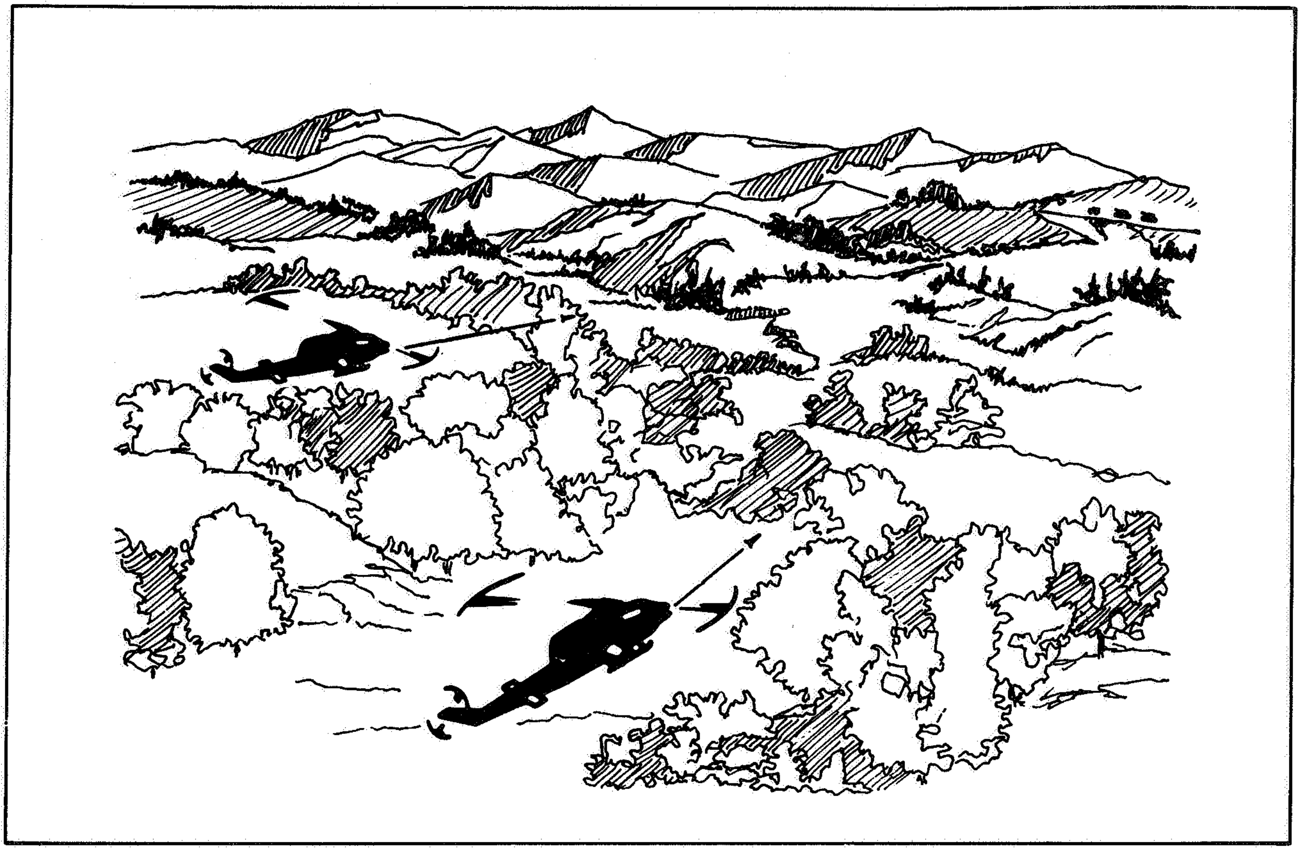


Figure 7-10. Firing Using Terrain Mask

Upon order to terminate the attack, the attack helicopters will remask and depart the attack position along a preplanned route to an alternate attack position or return to a forward arming and refueling point.

7.8.1 Covering Points (CP). The prerequisites for covering points are the same as those for firing points; however, a few other characteristics are desirable. Covering points are used by the covering element in support of a TOW attack. Actions at the covering points are not only restricted to firing, but may include mission control, control of supporting arms, performance of deceptive maneuvers, and providing flank/rear security for the attacking element. It is not only essential that the entire kill zone be viewed by a combination of covering points, but approaches to the kill zone as well. When targeting by other supporting arms occurs outside the kill zone, this sector must be observed from a covering point.

7.9 FIRE COMMAND

Whether using attack helicopters for CIFS or anti-armor missions, a standard briefing for location of targets is used. To reduce the number of unique briefing formats in use, attack helicopters shall use the Close Air Support (CAS)/Close-In Fire Support (CIFS) Briefing Guide (Figure 7-11).

7.9.1 Sample Brief. Upon arrival at the holding area, the flight leader receives a brief from the FAC (see Figure 7-12). The flight leader now has all the information he needs to conduct his interflight coordination and attack his assigned target (Figure 7-12).

7.9.2 Battlefield Organization. (Refer to Figure 7-13.)

7.9.3 Interflight Coordination. After the flight leader has received his target brief, he still must accomplish his interflight coordination to enable his flight to deploy correctly in the attack position. This is best accomplished by a squadron tactical SOP and associated kneeboard card utilizing code words for brevity. Figure 7-14 gives an example of a kneeboard card which would provide the flight crew with the information they need. After passing the interflight information, the individual flight member, using the firing charts contained in Appendix I, computes his sight setting and ordnance time of flight.

7.9.4 Attack Positions Actions. Once the flight is positioned in the attack position, the flight need only unmask and acquire the mark/target (5 to 10 seconds for target acquisition plus ordnance time of flight) prior to TOT/TTT. Once the proper amount of ordnance has been fired or effect on target has been achieved, the flight should exit the AP as soon as possible to avoid enemy counterfire. Figure 7-12, line 9, gives an egress of Juliet which is the control point at which the flight should rendezvous.

1. IP ____________________	Attack position (AP).
2. HDG ____________________	The magnetic heading from the center of the AP to the target.
3. DIST ____________________	The distance from the center of the AP to the target in meters.
4. TGT ELEV ____________________	Target elevation (ft).
5. TGT DESC ____________________	Target description.
6. TGT COORD ____________________	Target coordinates.
7. MARK TYPE ________ CODE ________	Mark type. Laser code if using Hellfire.
8. FRIENDLIES ____________________	Location of nearest friendly troops expressed in cardinal heading and meters.
9. EGRESS ____________________	Egress after attack.
10. BCN-TGT ____________________	For Hellfire, Mule to Target Heading.
11. BCN-TGT ____________________	For Hellfire, Mule to Target Distance.
12. BCN-ELEV ____________________	For Hellfire, Mule Elevation

13. TIME TO TARGET/TIME ON TARGET __________ (MIN) "HACK"
Time ordnance is to be impacting the target.

REMARKS:

Figure 7-11. CAS/CIFS Briefing Guide

"Alpha

270

3100

2577

APCs

PH343217

Willie Pete

2000 South

Juliet

Time to Target 6+00 HACK"

Figure 7-12. Sample Brief

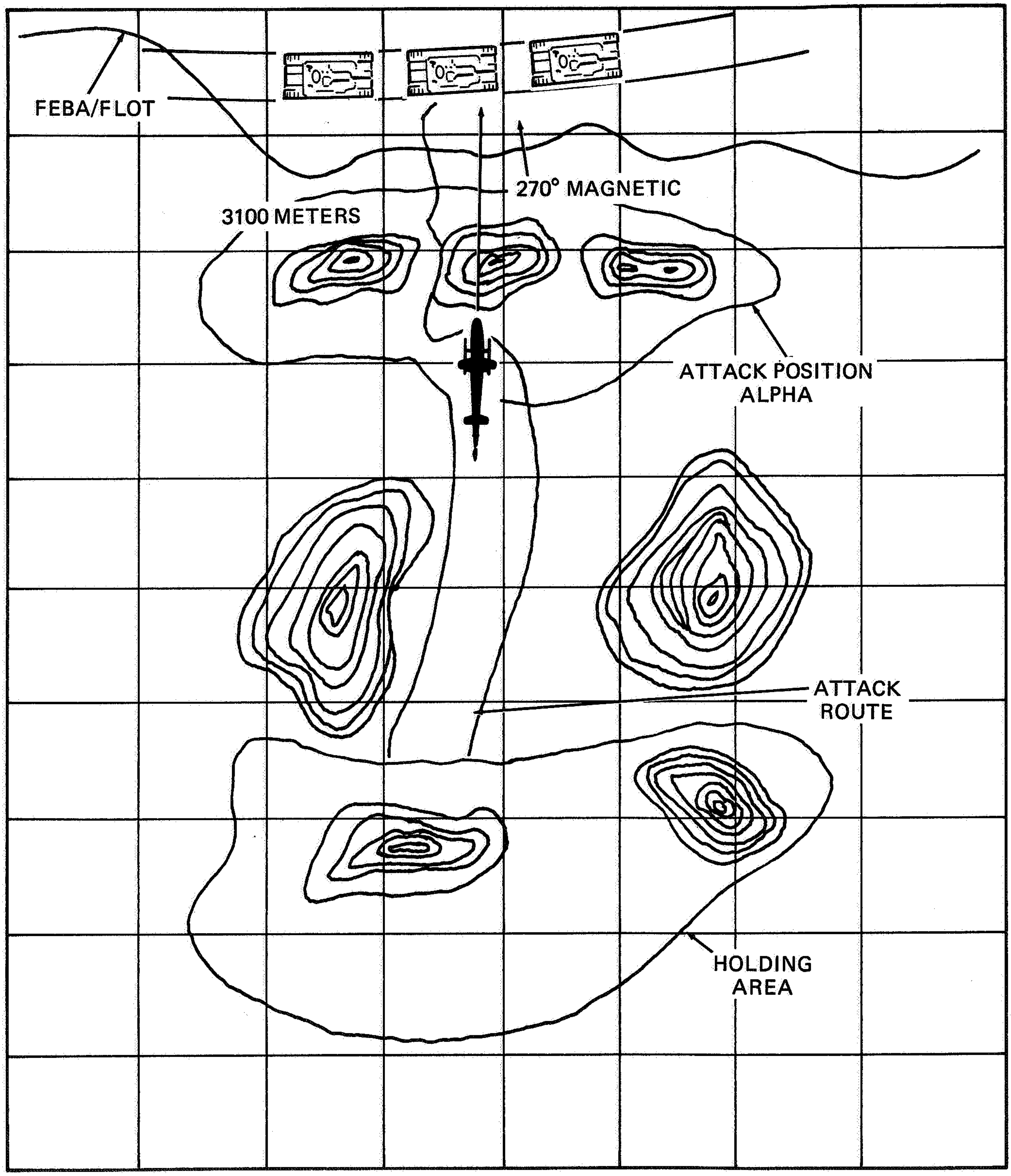


Figure 7-13. Battlefield Organization

ATTACK POSITION ACTIONS

1ST LETTER
FIRING MODE

H – HOVER FIRE
R – RUNNING FIRE
P – POP-UP FIRE
D – DIVING FIRE

2ND AND 3RD LETTER
COVER ELEMENT POSITIONS

CL – COVER LEFT
CR – COVER RIGHT
CC – COVER CENTER
CS – COVER SPLIT

4TH LETTER
ORDNANCE TYPE

T – TOW
H – HIGH EXPLOSIVE ROCKETS
W – WHITE PHOSPHOROUS ROCKETS
F – FLARE ROCKETS
M – 20 MM
A – AIM-9
S – SIDEARM
L – HELLFIRE

5TH NUMBER
ORDNANCE QUANTITY

1 – ONE
2 – TWO
ETC.

REMARKS (IF NECESSARY)

RACKTRACK, BUTTERFLY, ETC.

Figure 7-14. Attack Position Actions

CHAPTER 8

Attack and Fire Support Patterns

8.1 TARGET ACQUISITION

Before engaging a known target or a target of opportunity, the task of the attack helicopter crew is to locate the target on the ground.

8.1.1 Reconnaissance. Thorough reconnaissance is necessary for either a known target location or for targets of opportunity.

8.1.2 Known Target. The known target is detected by some type of aerial surveillance or method of ground surveillance. The mission is given to the attack helicopter flight. Their task is to pinpoint the target specifically before attacking it. To accomplish their task, the factors of mission, enemy, terrain, weather, troops (METT), and the established rules of attack helicopter employment must be considered. Based on this analysis of the target, the attack element then performs a reconnaissance of the target area by flying at the best altitude for observation, depending on the terrain, vegetation, and enemy situation. The attack helicopter flight must find a position from which to best determine exactly what the target is, what it looks like, and where it is located. Once this has been determined, the leader of the element can form his plan of attack and issue his fire command.

Before sending the helicopter flight to attack a known target, aerial photography can be helpful in locating it. Aerial photography often gives the first indication that a target is in the area. If possible, a visual reconnaissance should be made before attacking a target identified by a photograph.

8.1.3 Targets of Opportunity. Surprise targets which the attack helicopter flight reconnaissance happens to locate are targets of opportunity. They may be spotted visually by the crew, or they may disclose their positions as a result of enemy fire directed toward the attack helicopter flight.

Targets spotted by the crew may be picked up by movement, fresh digging, trails, smoke of campfires, poorly camouflaged huts, fortifications, and many other clues that can arouse suspicion in the search area.

Reconnaissance by fire is another method of locating targets. This causes a poorly disciplined enemy to move or to return fire and thus give away his position.

Targets may be located by drawing enemy fire, even when not employing reconnaissance by fire. This is frequently the case when conducting a reconnaissance mission or escorting troop helicopters en route. In either situation, some method of pinpointing the location must be used.

Often the enemy fire will pinpoint the target; but, if tracers, smoke, muzzle flash, or other motion is not detected, some sort of search of the general area must be conducted to locate it. Conduct of this search must be determined by and based on the factors of METT. Normally, the attack helicopter flight leader must request permission of the ground commander of higher headquarters to engage the target.

WARNING

Care must be taken to ensure that targets of opportunity have been confirmed as the enemy.

8.1.4 Spot Reports. This type of report must include the following information:

1. Observer identification.
2. Description of target.
3. Location of target.
4. Activity — what is the target doing (e.g., moving convoy, troops moving, and so forth).
5. Requested action.

8.2 TARGETS ACQUIRED BY GROUND OBSERVERS

Ground elements acquire many targets for the attack helicopter. Transmitting target information from the ground element to the attack helicopter flight causes special problems. These problems are compounded during night operations or periods of low visibility. A simplified fire request system must be used by the ground observer to minimize the difficulties of calling for attack helicopter support. Usually this is accomplished by radio as a result of an exchange of special operating instructions between the ground element and the attack helicopter flight.

8.2.1 Friendly Elements Position. The ground observer and the attack helicopter flight leader must be sure that the attack helicopter flight knows the location of the friendly elements on the ground. Signal mirrors, colored smoke, or marker panels by the ground units are some of the means of positive position identification.

8.2.2 Marking Target. The ground observer can mark or reference the target by using any means which can be identified from air.

8.2.3 Direction of Target. A preferred method is to give a magnetic azimuth from friendly position or the mark to the target. Range from the mark or friendly position should be as accurate as possible.

8.2.4 Describing Target. Care must be taken to describe the target, using a means that can be identified from the air and the ground. The ground observer should inform the attack helicopter commander of the type and intensity of enemy fires existing or suspected in the target area.

8.2.5 Type of Weapon Desired. If there is a preference, the ground observer should let the attack helicopter command know that type weapon he desires:

1. Rifle-bored weapons only (20 mm)
2. Rockets only
3. Missiles only
4. Any combination of weapons.

8.2.6 Adjustment by Ground Observer. The ground observer must be prepared to adjust initial fires of the attack helicopter using the observer target line.

8.3 TARGET ANALYSIS

Target analysis is an examination of the target environment and physical characteristics related to the factors of mission, enemy, terrain, weather, and troops (METT). Whether the target is acquired from a photographic study, aerial reconnaissance, or during the conduct of an operational mission, the considerations remain the same — only the time available for planning varies. The following factors of METT should be analyzed:

1. Mission — destruction, neutralization, or combined.
2. Enemy
    (a) Type target — personnel: number, activity and disposition; prepared or hasty positions; moving or stationary. Material: protected or unprotected; combustible;

structural resistance. Vehicles: number and type; armored and unarmored; moving or stationary; accompanied by infantry. Weapons: type capabilities; means of target acquisition; fields of fire.

(b) Defense — type and number and location of antiaircraft weapons, enemy air.

3. Terrain/Weather

(a) Avenues of approach and retirement, prominent terrain, vegetation, and surface condition.

(b) Visibility, ceiling, winds, and precipitation.

4. Troops

(a) Friendly troops in the area and en route to the target area.

(b) Friendly air, artillery, and naval gunfire in the area that is either active or available for use.

8.4 GENERAL SELECTION

After the target analysis, the pilots will select the ordnance that will best accomplish their mission by comparing the required results against the capabilities of the ordnance available. Generally, guns will be employed against troops in the open or in lightly protected positions; rockets and guns against troops who are protected in wooded areas or lightly armored vehicles; missiles against tanks, armored vehicles, or other hard targets; or combinations of the above weapons according to the nature of the target. The Joint Munitions Effectiveness Manual should be consulted for the best munition to use against a specific target when time permits.

8.5 EN ROUTE CONSIDERATIONS

The following factors should be considered during mission planning: formation, altitude, and route. Additionally, the factors of METT and the boundaries or limitations of restricted fire plans should be considered.

8.5.1 Formations. Whether en route or in the operating area, the attack helicopter flight leader must position his flight to allow for maximum freedom of movement while maintaining tactical integrity. The formation to be used will be chosen after careful analysis of the mission and the anticipated enemy opposition along the selected route. The requirements for mutual support by both observation and fire and maneuverability must be weighed against one another. The three most common types of formations are the tactical cruise, the combat spread, and the free cruise (tail chase).

8.5.2 Route Selection. The route that a flight of attack helicopters will take to an operating area must be carefully considered. The factors of METT should be used as a convenient checklist, with the emphasis being placed on the safety of the flight and the need for tactical surprise.

8.5.3 Altitude Selection. The altitude to be flown en route and during the attack mission should be carefully considered by the attack helicopter pilot. The altitude will be determined by the enemy's weapons capabilities, the weather in the operating area, and the requirement for surprise prior to the attack. The basic decision will be whether the flight will operate at high or low altitude.

8.5.4 Attack Patterns and Formations. Normally, specific attack patterns cannot be preplanned; however, certain considerations apply to all patterns. The flight leader will adjust each attack to take advantage of the terrain and weather, exploit enemy weakness, and employ his aircraft to gain the maximum advantage. Important conditions in the selection of an attack pattern include the number of attacking aircraft, the target characteristics, weapons capabilities, friendly forces in the immediate area, the disposition of enemy defenses, and the requirement for a change in direction of subsequent attack passes.

8.5.4.1 Racetrack Pattern. The racetrack pattern (Figure 8-1) is the basic attack pattern for which the others are derived. This pattern may be used on any mission or may be modified as the situation dictates.

8.5.4.1.1 Advantages

1. Any number of helicopters may be used in the pattern.
2. Continuous fire may be placed on the target.
3. Engagement range, disengagement range, and timing are flexible.
4. The flight leader has good control over the attack.

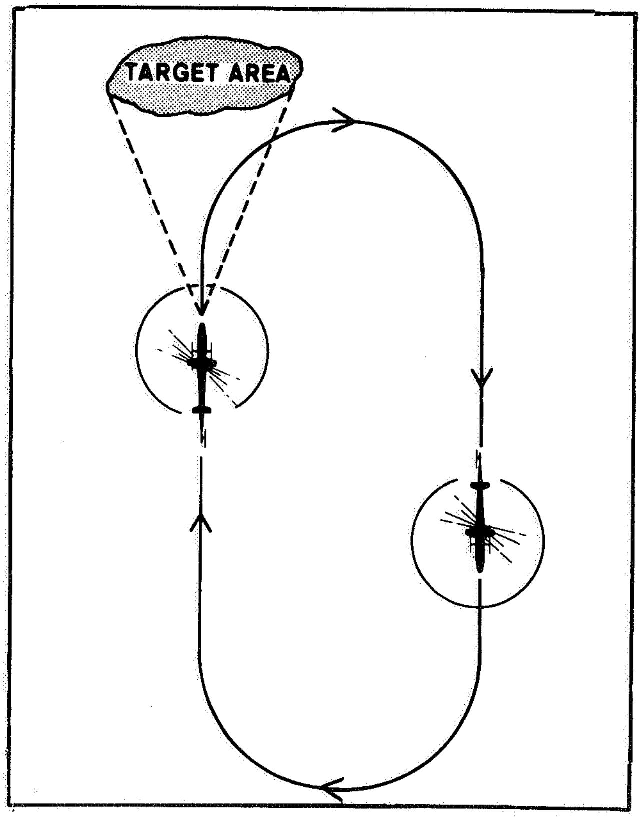


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Figure 8-1. Racetrack Pattern

8.5.4.1.2 Disadvantages

1. Target is covered from only one direction at a time.
2. Enemy is able to place enfilade fire on the entire attack formation from one position.
3. Only one helicopter can engage the target at a time.

8.5.4.2 Cloverleaf Pattern. The cloverleaf attack pattern (Figure 8-2) may be employed during destruction missions against point or small area targets. The number of leaves will vary with the enemy situation during the attack. Generally, the larger the requirement for mutual support, the larger the number of leaves.

8.5.4.2.1 Advantages

1. Changing direction for each attack prevents enemy concentration of fires in anticipation of subsequent attacks.
2. Good target coverage from several directions requires enemy defenses to be constructed for all-around protection.
3. By placing continuous fire on the target, this attack prevents enemy movement to reposition forces.
4. Engagement range, disengagement range, and timing of attack are flexible.
5. Mutual support is possible and the flight leader can maintain control of the attack.

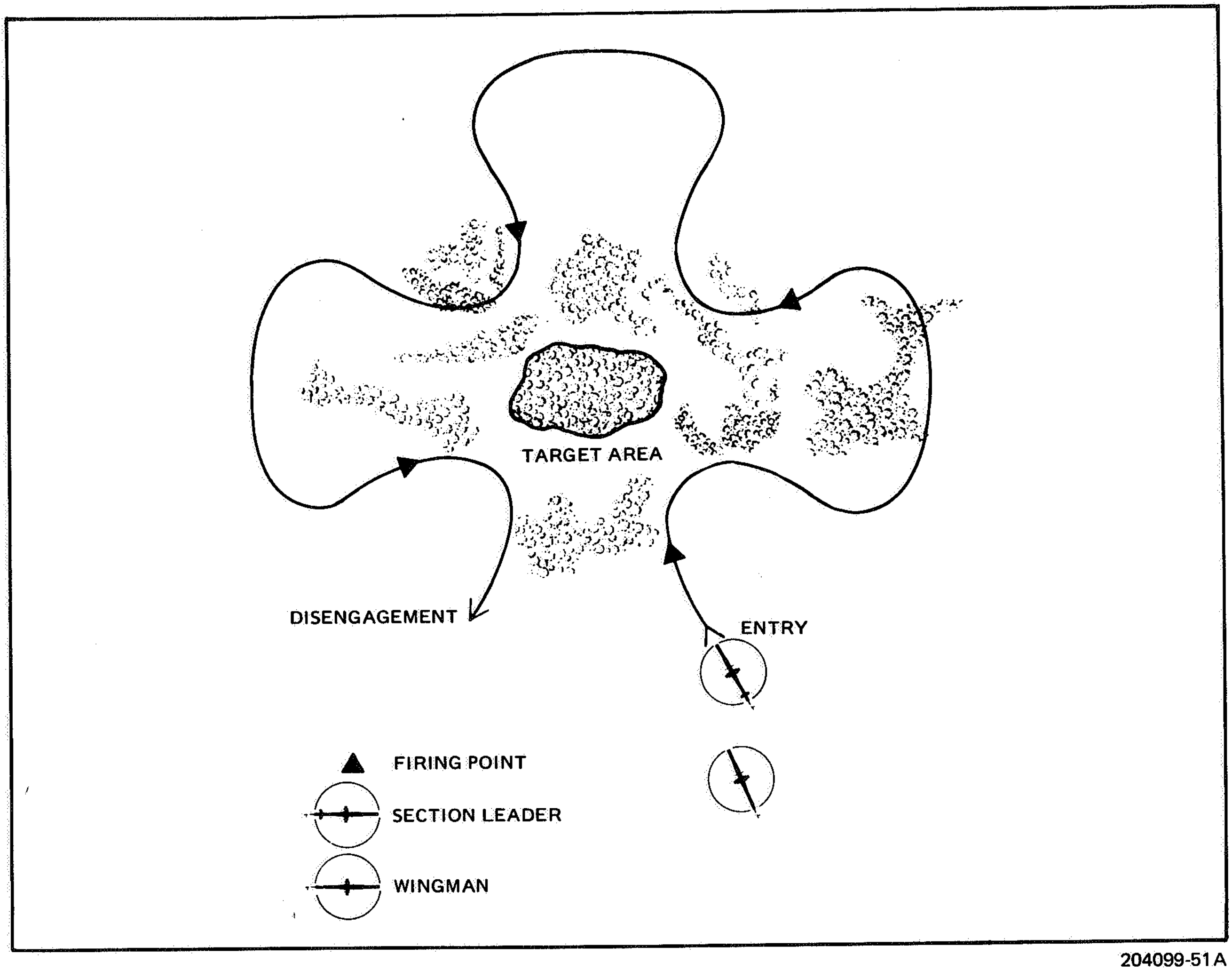


Figure 8-2. Cloverleaf Pattern

6. The pattern may be modified to adapt to the terrain and the number of firing passes required.

7. Initial entry and the attack pass can be established at any point.

8.5.4.2.2 Disadvantages

1. Hostile areas may be overflown.

2. Care must be exercised not to fire into adjacent friendly positions.

8.5.4.3 L-Pattern. The L attack pattern (Figure 8-3) is most effective against targets requiring a large volume of fire for a short

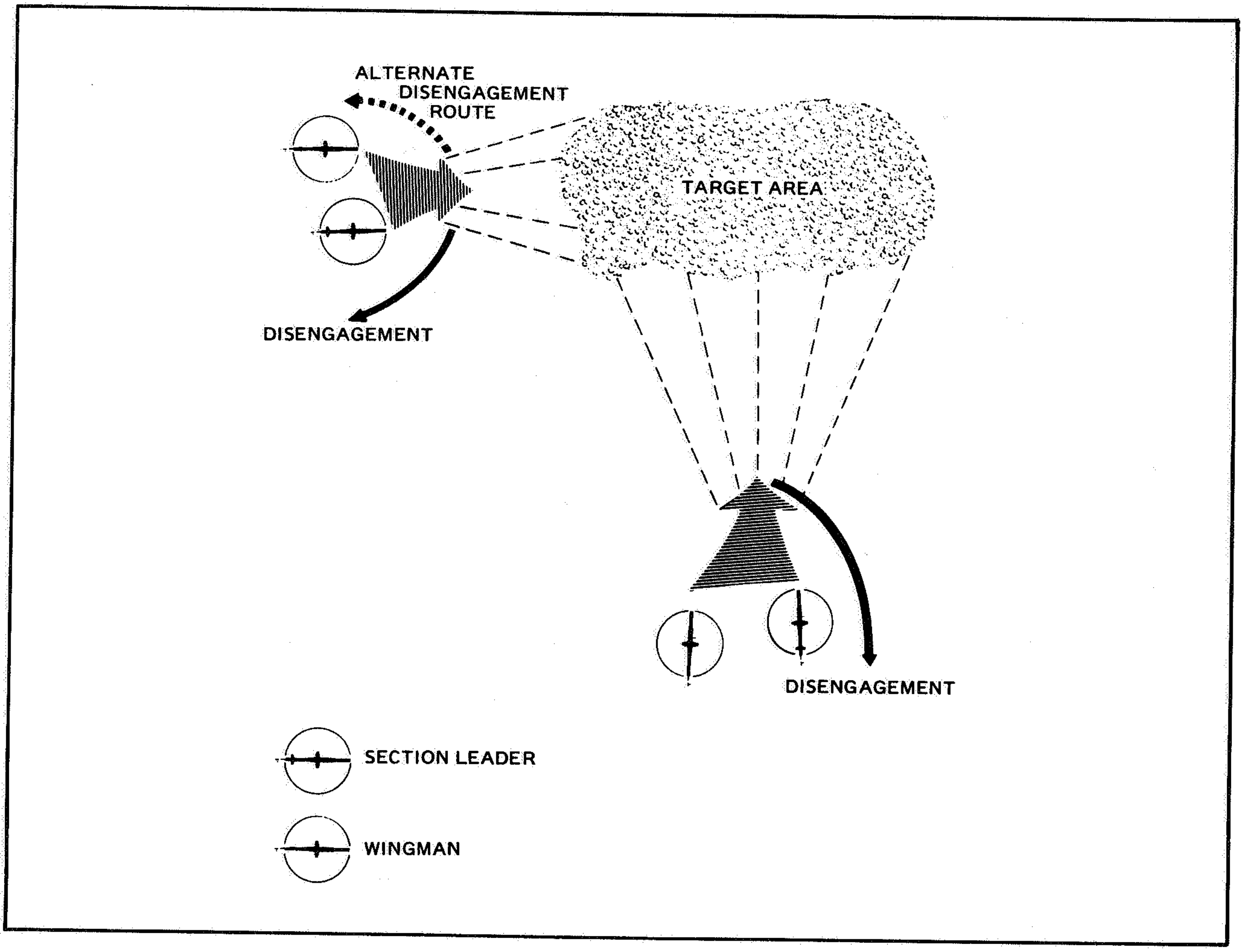


Figure 8-3. L Attack Pattern

duration. The L-pattern is capable of attacking linear targets or targets that are masked on one side by high terrain. If a large volume of fire is not required, proper timing allows one helicopter at a time to fire neutralization fire for a sustained period.

8.5.4.3.1 Advantages

1. The enemy is fixed during the period of maximum fire delivery.
2. Surprise and speed of attack limit exposure of the helicopter to return fire for minimum periods of time.
3. Good target coverage is obtained from two directions simultaneously.
4. The beaten zone of at least one attacking element will generally correspond to the long axis of the target.
5. The enemy is forced to defend in two directions simultaneously.

6. Maximum engagement and minimum disengagement ranges are allowed by this pattern.

8.5.4.3.2 Disadvantages

1. Control, timing, and formations are critical.

2. Enemy position must be known.

8.5.4.4 45° Attack. The 45° attack (Figure 8-4) is most effective when only one run on the target is contemplated or when used to disengage from an area where the flight is taking fire. Flexible guns are used by both aircraft for mutual cover; generally, the wing aircraft can accurately fire rockets on the target within 2 to 3 seconds after the leader commences fire.

8.5.4.4.1 Advantages

1. Provides maximum ordnance on target for a short duration.

2. Control is easily maintained.

3. Engagement and disengagement ranges are variable.

8.5.4.4.2 Disadvantages

1. Covers the target for only one direction.

2. Aircraft are not mutually supporting during the pull-off.

3. Successive runs are difficult.

8.5.4.5 Circular Pattern. The circular pattern (Figure 8-5) is most effectively flown in either a left or right orbit around the target with the attack helicopters equally spaced around the circle. Altitude may vary as necessary. As altitude increases, orbit diameter must increase so that the attack helicopter may roll in from the orbit and be in the proper dive angle to attack the target at any time.

8.5.4.5.1 Advantages

1. 360° observation of the target.

2. Both aircraft are in position to employ all weapons at any time.

3. All escorts aircraft are oriented to the target.

8.5.4.5.2 Disadvantages. Exposed 360° fire around the target.

8.5.5 The Pull-Off. The pull-off is employed to enable attack helicopters the safest possible departure from the target area. Three basic pull-offs will be discussed below for pilot consideration.

8.5.5.1 Descending Pull-Off

8.5.5.1.1 Advantages

1. Descending affords one more parameter for which an enemy gunner must compensate.

2. Gain in airspeed.

3. The g-loading is lower on a heavily loaded airframe.

4. Permits return to the nap-of-the-Earth flight.

8.5.5.1.2 Disadvantages

1. More time required to return to an attacking altitude.

2. Caution must be executed in maintaining terrain clearance.

3. More susceptible to ground fire.

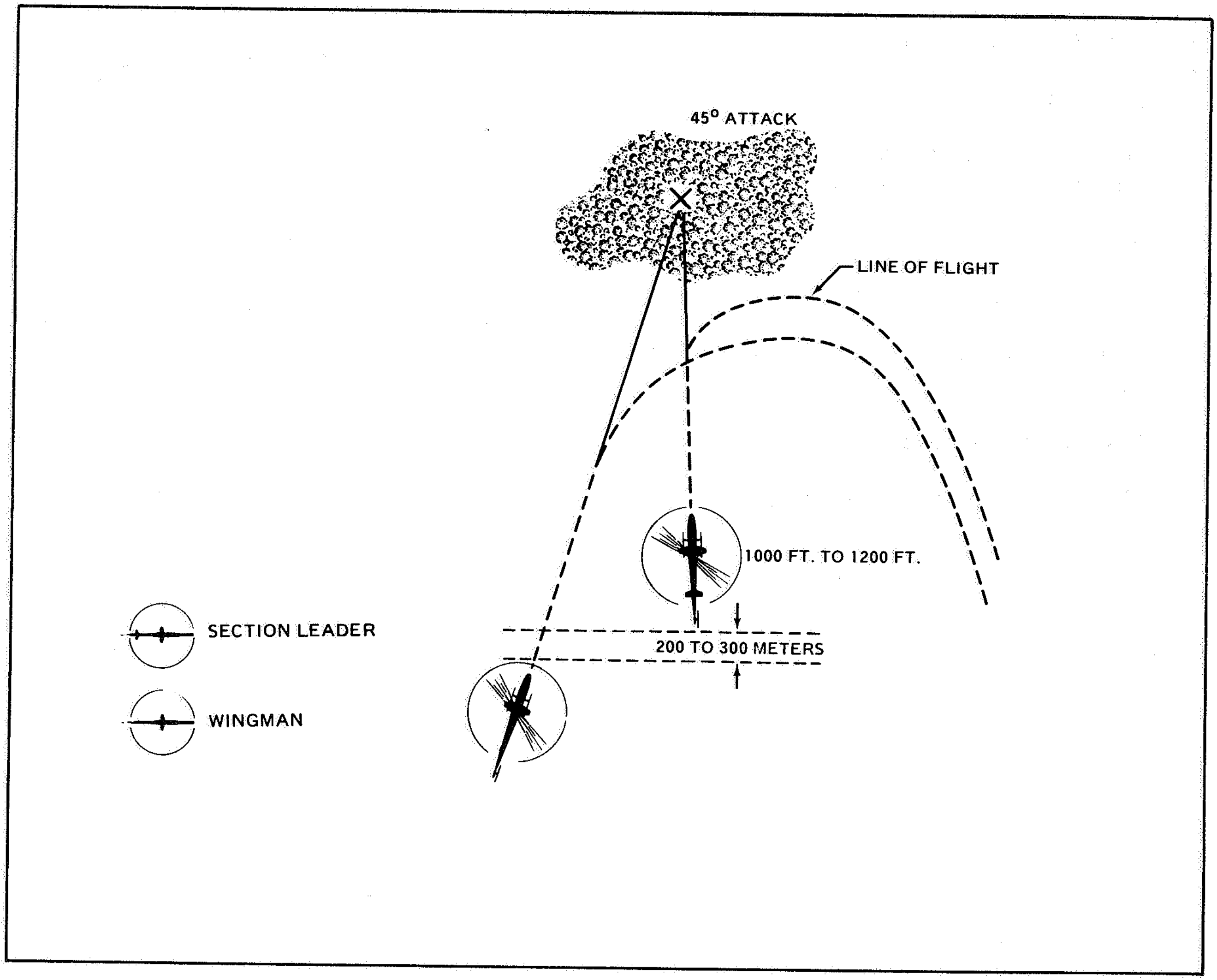


Figure 8-4. 45° Attack Pattern

8.5.5.2 Level Pull-Off

8.5.5.2.1 Advantages

1. Maintains airspeed
2. Maintains altitude
3. Allows for terrain clearance.

8.5.5.2.2 Disadvantages

1. Allows enemy gunners to aim for only range and turn rate, but not altitude.
2. G-loading on aicraft may approach airframe design limits.

8.5.5.3 Climbing Pull-Off

8.5.5.3.1 Advantages

1. Climbing affords one more parameter for which an enemy gunner must compensate.

2. Quick return time to altitude.

3. Terrain clearance enhanced.

4. Minimum time spent in the small arms environment.

8.5.5.3.2 Disadvantages

1. Climb is generally at slow airspeed.

2. G-loading on aircraft may approach airframe design limits.

8.5.6 Airborne Mission Briefing. Prior to a helicopter attack, it is important that the flight leader brief all members of his flight on the proper conduct of the attack. The following elements are set forth as minimum guidelines:

1. Target description

2. Target location

3. Location of the nearest friendly troops

4. Attack heading

5. Pull-out direction

6. Ordnance to be employed (type and amount)

7. Target elevation.

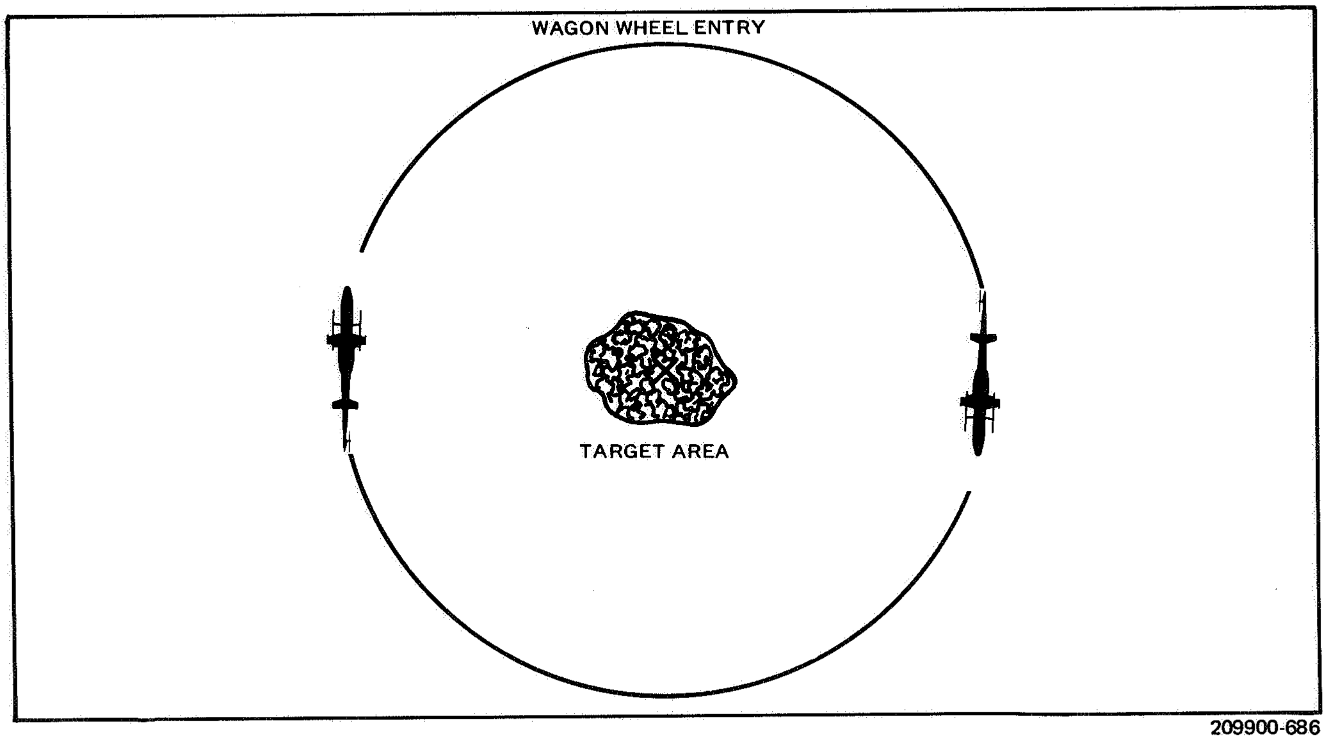


Figure 8-5. Circle Pattern

CHAPTER 9

Reconnaissance

9.1 GENERAL

Effective reconnaissance provides much of the information concerning the enemy, terrain, and weather essential to the conduct of operations. When employed with conventional surface reconnaissance elements, attack helicopters extend the overall reconnaissance effort. During reconnaissance operations, attack helicopters will actively engage in offensive action as required. The purpose of reconnaissance is to gather information upon which commanders may base plans, decisions, and orders. It is conducted continuously as part of all operations and to develop a situation for the main body. Reconnaissance can be best conducted by combining the efforts of both air and ground elements. It may be a distinct mission or part of another operation. Air assets can greatly reduce the time needed to reconnoiter. The magnification characteristics of the TSU in both 2x and 13x optics provide for observation of an area at extended ranges. This capability negates the need for the aircraft to fly over a hazardous area which may not be survivable and reduces the possibility of compromising friendly movement and intentions. While this is not the most effective use of the AH-1, certain situations may dictate implementation.

9.2 PRINCIPLES OF RECONNAISSANCE

9.2.1 Reconnaissance Objective. Attack helicopters performing reconnaissance must maneuver according to the location or movement of the reconnaissance objective. This objective may be stated as enemy troops, terrain features, or a locality. Reconnaissance missions must be allowed maximum freedom of action within mission restrictions.

9.2.2 Accurate Information Report. Reconnaissance is conducted to obtain useful combat intelligence. This information must include who, what, when, and where. The crews of attack helicopters conducting reconnaissance missions must report all pertinent information rapidly and accurately. The use of reconnaissance spot reports will facilitate the rapid transmission of essential information. Information appearing unimportant may be very valuable when used in conjunction with other information.

9.2.3 Offensive Action Situation. When enemy contact is established, the situation should be developed quickly by limited offensive action unless restricted by the mission. The enemy's location, strength, composition (to include major supporting weapons in the immediate area), and disposition are determined, with special effort being made to determine the weaknesses in his positions. Reconnaissance by fire may assist in this mission. Attack helicopters may be assigned the mission of armed reconnaissance and neutralization of certain enemy targets.

If the enemy does not detect the initial contact, reconnoitering flights continue observation until:

1. Detected.

2. Mission accomplished.

3. Further development of the situation requires combat action.

4. Need for speed dictates sacrificing stealth.

5. Told to bypass by higher headquarters.

If contact results in exchange of fire:

1. Overwatch elements lay down a heavy volume of direct suppressive fire and request indirect fires, if necessary and available.

2. Bounding elements (normally the first to be engaged) return fire while seeking cover.

3. Situation is reported and developed by fire and maneuver.

4. After the situation is developed, the flight chooses a course of action and reports. This ensures the commander's approval and provides him information needed to develop his course of action.

9.2.4 Low-Level Observation Techniques. As a rule of thumb, the slant range to the horizon at NOE altitude is about 3,200 feet or approximately one map grid square. The maximum detection range for practically all targets of interest will be less than 3,200 feet. For example, the maximum distance or range at which you can detect large targets such as the M-48 tank or a 155-mm, self-propelled Howitzer is about 2,800 feet. Consequently, you do not need to go above NOE altitude to stay within the optimum visual search range of vision or, in other words, within the maximum detector range for targets.

9.3 TYPES OF RECONNAISSANCE MISSIONS

Attack helicopter units may conduct reconnaissance missions in support of both ground and aviation units. There are four types of reconnaissance missions: route, area, point, and line.

9.3.1 Route Reconnaissance. Route reconnaissance is obtaining information along a specific route and the terrain adjacent to the route which, if occupied or utilized by the enemy, would affect the tactical situation (Figure 9-1).

A route reconnaissance may be requested to obtain information of a specific route or of an enemy force moving generally along a specific route. When intelligence indicates that the enemy is moving on one or more routes, or when terrain features channelize his advance, these routes should be reconnoitered to obtain enemy information. Routes of advance or flight routes may be reconnoitered when specific information of the route is required for the movement of friendly forces. Detailed route reconnaissance may be performed in conjunction with ground reconnaissance elements, especially when the route traverses densely vegetated or built-up areas.

9.3.1.1 Formations and Techniques. A map study of the route will be conducted prior to a reconnaissance mission. When available, aerial photographs should supplement this study.

Normally, the attack helicopter flight will carry a mixed load of weapons and ammunition with adequate firepower to conduct armed reconnaissance.

Prior coordination for artillery, naval gunfire, or fixed-wing assistance to provide on-call fires or close air support should be made. This coordination will include the type and amount of firepower requested, communications frequencies, and call signs.

The attack helicopters should reconnoiter the main route. During the mission, they will employ reconnaissance as required.

When moving along a route, a distance from the route and an altitude which allows the best reconnaissance of the route should be used. This distance and altitude will vary according to METT factors. Particular attention should be given to flightpaths offering the best observation of the route, mutual fire support, and avoidance of probable enemy locations. The flightpath should be varied to preclude establishing a set pattern that can be easily predicted by the enemy.

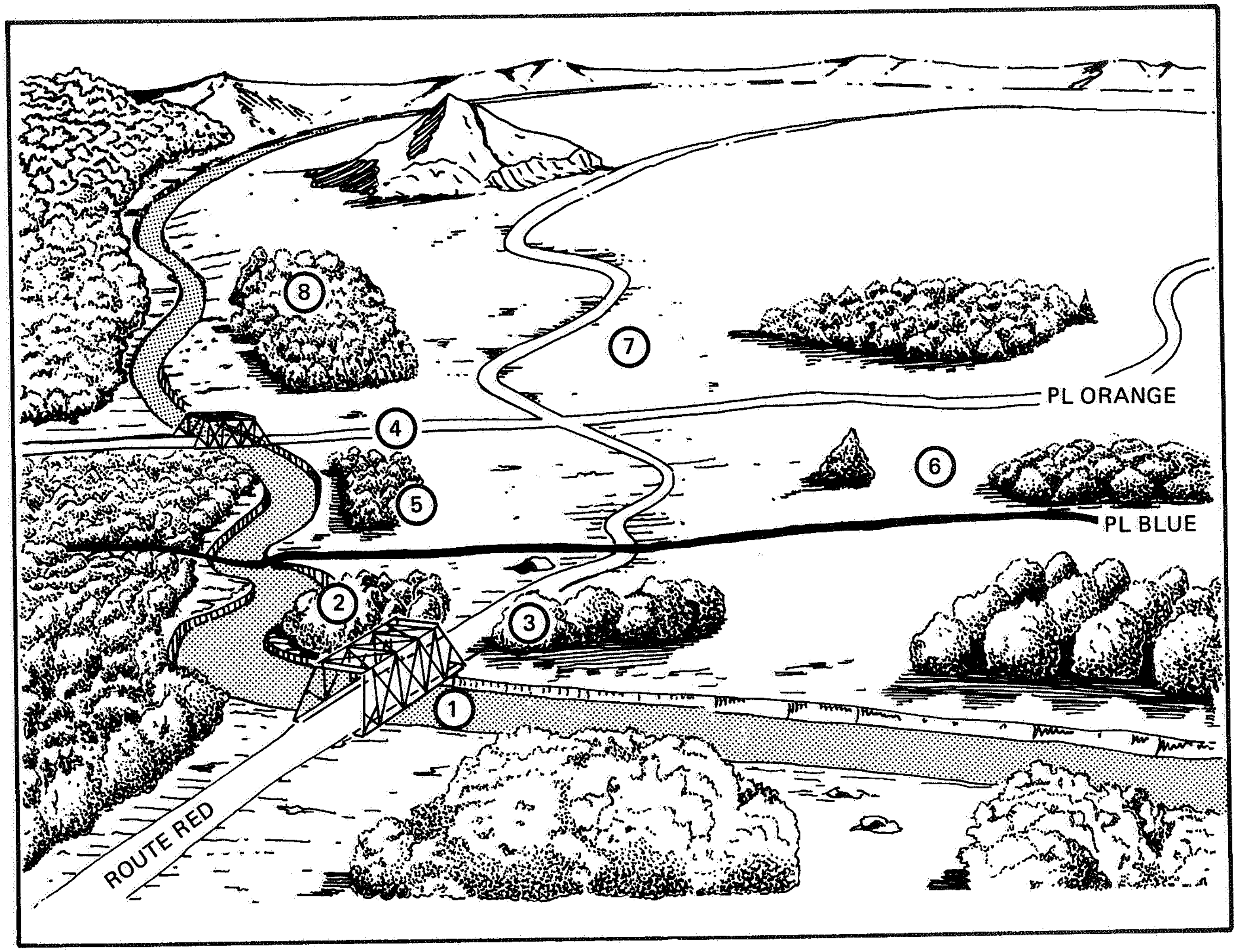


Figure 9-1. Route Reconnaissance

To prevent enemy observation and fire, dominant terrain within range of the route should be reconnoitered immediately.

Easily recognizable checkpoints should be used for control throughout at the route reconnaissance.

The initial actions upon contact with the enemy must be planned and understood by all flight members.

9.3.1.2 Purpose. A route reconnaissance mission is assigned to obtain detailed information on a specified route and all adjacent terrain from which the enemy could influence movement along that route. Route reconnaissance may be oriented on a road, an air route, an axis, or a general direction of advance.

A route reconnaissance mission may also be assigned to obtain information:

1. On an enemy force moving generally along a specific route
2. To develop the enemy situation ahead of a friendly force
3. To locate sites for construction of hasty obstacles to impede enemy movement
4. To support movement of supply or other type units.

9.3.1.3 Mission Information. In order to perform a route reconnaissance, certain information *must* be provided the aviator/observer team:

1. Route designation — it may consist of a name (e.g., Highway 84, Jones Road), a trace of the route, or coordinates along the route.
2. Limits of the route — this may be indicated by coordinates or any definite ground reference such as road junctions, towns, bridges, and so forth.

Information which *should* be provided the aviator/observer, if available:

1. Time the route will be used — this may change the desirability of using a route. At night, curves and narrow roads are more critical than during daylight hours.
2. Type and number of units or vehicles — this is an important factor in determining if a route is usable. Route requirements of infantry, armor, artillery, or truck units will be different. A few tanks may ruin the surface of a route, although many truck units could pass without difficulty.
3. Any specific information required by the unit commander.

9.3.1.4 Route Reconnaissance Missions

9.3.1.4.1 Ground Routes In reconnaissance of ground routes, roads, bridges, tunnels, underpasses, and cross-country segments must be checked.

a. Roads. Classification takes into consideration many factors:

1. Type surface — concrete, asphalt, sand.
2. Width — estimated and expressed in number of lanes (i.e., two lanes for 2-1/2-ton truck traffic and one lane for M-60 tanks).
3. Drainage — of primary consideration are gravel, clay, or sand roads. Check for crown. Watch for water standing in road and in ditches during wet seasons.
4. Surface conditions — continually watch for combat damage, cuts, craters, dirt slides, ruts, cracks, or excessive erosion.
5. Grades and curves — very steep grades and sharp curves will reduce the usage of the road and are likely enemy ambush sites.
6. Drive-off capability — shoulder condition, width, and slope will determine capability to park vehicles off the roadway. Trees that overhang the shoulders will offer limited concealment to parked vehicles.

b. Bridges, Tunnels, Underpasses. These are very difficult to classify from aerial observation. The aviator/observer must consider many factors in making this observation. In some cases, it may become necessary to land and dismount to make the classifications. Bridges are reconnoitered for location, type, condition, dimensions, bypass capabilities and load-carrying capacity. Tunnels and underpasses are reconnoitered for locations, dimensions, and bypass capabilities.

1. Type of construction and condition — steel, concrete, wood, or brick; if the bridge has received combat damage, will it need repair before use?

2. Length and width — estimate length of one span and multiply by number of spans. The width is estimated and expressed in number of lanes (i.e., two lanes 2-1/2-ton truck traffic). The observer may use map distance for estimating tunnel length.

3. Clearance — tunnel and underpass clearance are measured from the road surface to the lowest overhead obstruction.

4. Location — check the accuracy of the map location or bridges, tunnels, and underpasses.

5. Bypassing — always look for a bypass regardless of the condition of the bridge, tunnel, or underpass. There are three bypass conditions as follows:

(a) Bypass easy. The obstacle can be crossed within the immediate vicinity of the bridge by a U.S. 2-1/2-ton, 6 X 6 truck or NATO equivalent without work to improve the bypass.

Note

For standardization, immediate vicinity is defined as a time span of not more than 15 minutes or 4 miles (6.5 km), ground time round trip for the unit which is planning to use the route.

(b) Bypass difficult. The obstacle can be crossed within the immediate vicinity of the bridge, but some work will be necessary to prepare the bypass.

Note

If engineer support is required, the bypass should be considered difficult, unless the unit has the organic capability or equipment to rapidly cross the obstacle.

(c) Bypass impossible. The bypass can only be crossed by one of the following methods:

(1) Repair of existing bridge.

(2) Construction of a new bridge.

(3) Bridge detour — an alternate route that crosses the obstacle at some distance from the bridge site. It will normally follow existing roads.

c. Cross-Country Segments. A careful reconnaissance of critical terrain (i.e., high ground passes) must be made and any conditions that would slow traffic must be reported.

d. Ground Route Classification. A ground route is classified by width, type, and road carrying capability. A route, like a chain, is only as strong as its weakest link. If a large portion of the route is four-lane expressway, but a small segment is two-lane gravel, the overall route classification would be two-lane, limited all-weather medium. The method of expressing ground route classification is as follows:

1. Width — expressed in number of lanes (width of 2-1/2 ton truck) of the narrowest road comprising the route.

2. Type — the least desirable type road surface encountered. (Expressed as either "X," "Y," or "Z"-type roads.)

(a) All-weather (type "X") — any road that, with reasonable maintenance, is passable throughout the year to a volume of traffic never appreciably less than its maximum good-weather capacity. This type road has a waterproof surface and is only slightly affected by rain, frost, thaw, or heat. At no time is it closed to traffic due to weather effects, other than snow blockage. Example: Concrete, asphalt, brick, or stone.

(b) Limited all-weather (Type "Y") — any road that, with reasonable maintenance, can be kept open in bad weather to a volume of traffic which is considerably less than its normal good-weather capacity. This road does not have a waterproof surface and is considerably affected by rain, frost, and thaw. Example: Crushed rock or waterbound macadam, gravel, or lightly metalled surface.

(c) Fair weather (Type "Z") — a road that becomes quickly impassible in bad weather, and cannot be kept open by normal maintenance. This type of road is seriously affected by rain, frost, or thaw. Example: natural or stabilized soil, sand, clay, shell, or cinder.

3. Load-carrying capacity. Determined by the classification of the heaviest class vehicles that can use the entire route in convoy. This normally will be governed by the classification of the weakest bridge on the route. Otherwise, it is the load-bearing capacity of the road surface.

Note

Most bridges will have a weight class sign indicating the weight. Record the information even though it may be fake.

9.3.1.4.2 Air Route. The principles of an air route reconnaissance are the same as for a ground route; however, the areas of interest are different. The movement by air is concerned primarily with the location of enemy forces, hazards to flight (i.e., antiaircraft areas, overwater flight, wires, mountainous areas), ease of navigation, landing sites, and zones.

9.3.1.4.3 River. A river reconnaissance is performed in the same manner as a route reconnaissance with the exception that a river should be looked upon as an obstacle to the advancement of ground elements. Considerations are as follows:

1. Width
2. Depth
3. Rate of flow
4. Condition of banks and bed
5. Crossing sites
    (a) Manmade — established
    (b) Expedient—

9.3.1.5 Reconnaissance Recording. There are many acceptable methods for recording reconnaissance information. The method should be relatively simple, but must contain all pertinent information concerning the route. An acceptable method is to number all important features along the route as they are drawn on the map. Using a self-made form, write all pertinent information corresponding to the same terrain features on the map. This method gives a legible account of the route and does not clutter up the map which may have to be used again for another mission. A simple, abbreviated shorthand can be worked out by each individual. This worksheet will prove to be very valuable when making a route reconnaissance. A suggested format is divided into two sections, one for bridges and one for roads (Figure 9-2).

9.3.1.6 Mission Planning. The mission flight profile will be dictated by the threat. If contact is not possible or likely, such as in peacetime, a route reconnaissance mission can be accomplished by *one section* flying down the route and recording the required information. This technique is different from that used

TYPICAL ROUTE RECONNAISSANCE WORKSHEET

Bridge No.	Construction	Length	Width	Bypass	Other
1					
2					
3					
4					
5					
6					

Road Sec #	Construction (Surface)	Width	Drain	Drive-Off	Grades	Other
1						
2						
3						
4						

Figure 9–2. Typical Route Reconnaissance Worksheet

when enemy contact is possible or expected, in which case, a *minimum* of two flights will be employed along the route.

In either situation, the individual pilot should go through the premission planning with emphasis on a detailed map study to determine:

1. Type surface
2. Width
3. Surface
4. Grade and curves
5. Drive-off capabilities
6. Location of bridges, tunnels, and underpasses
7. Possible ambush positions

8. Long-range fields of fire on the route

9. Long-range observation points.

After studying the above information, the pilot picks a tentative route between the various points, using covered and concealed routes as ncessary.

The pilot then completes his premission planning (artillery, CPs, type movement, and so forth) and briefs the remainder of his team on how he plans to complete the mission.

Note

> If time is available, the pilot should construct a hasty route drawing or obtain a map on which mission information could be written for subsequent submission to flight operations.

The flight then flies the mission confirming the information determined from the map reconnaissance plus the following factors:

1. Drainage

2. Detailed bridge, tunnel, and underpass classification with bypass capability.

3. Enemy situations.

9.3.1.6.1 Route Reconnaissance If Enemy Contact is Possible

1. Flight organizations — if enemy contact is possible, a minimum of two flights should be employed.

2. Boundaries — the route is the boundary between flights. Each flight reconnoiters the terrain on its side out to the distance from which the enemy could employ direct fire on the route.

3. If terrain, thick woods, or underbrush prevent observation more than a few meters, the rule of thumb is to reconnoiter out a minimum of 1000 meters. Also, all interconnecting roads should be reconnoitered out to 3000 meters or the flight boundary, whichever is less.

4. If the route is straight, neither flight should fly down or cross the route until a reconnoitered 3000-meter buffer zone is established between the aircraft and the route. This is particularly important in close terrain, as the enemy will often use the road as a fire lane for a ZSU-23-4 or other dedicated antiaircraft weapons. Similarly, it is very dangerous to fly down a straight cut through heavily forested areas (Figure 9-3).

9.3.1.6.2 Planning for an Air Route. This type of reconnaissance is very similar to a ground route reconnaissance. During the map reconnaissance, the pilot should primarily look for observation points which offer fields of fire on the planned air route. The pilot then selects a tentative route utilizing covered and concealed routes as necessary to reconnoiter these observation points.

9.3.2 Area Reconnaissance. Area reconnaissance is the directed effort to obtain detailed information on all routes, terrain, and enemy forces within a specific area defined by boundaries. The purpose may be to locate enemy and/or suitable routes of advance for main elements (ground or air).

9.3.2.1 Use. An area reconnaissance normally is directed when the enemy's location is in doubt, when it is desired to locate suitable routes and determine cross-country trafficability within an area, or when other similar information is essential to the conduct of tactical operations.

9.3.2.2 Boundaries. The boundaries of an area reconnaissance to be performed by attack helicopters should be clearly defined and recognizable during low-level flight operations.

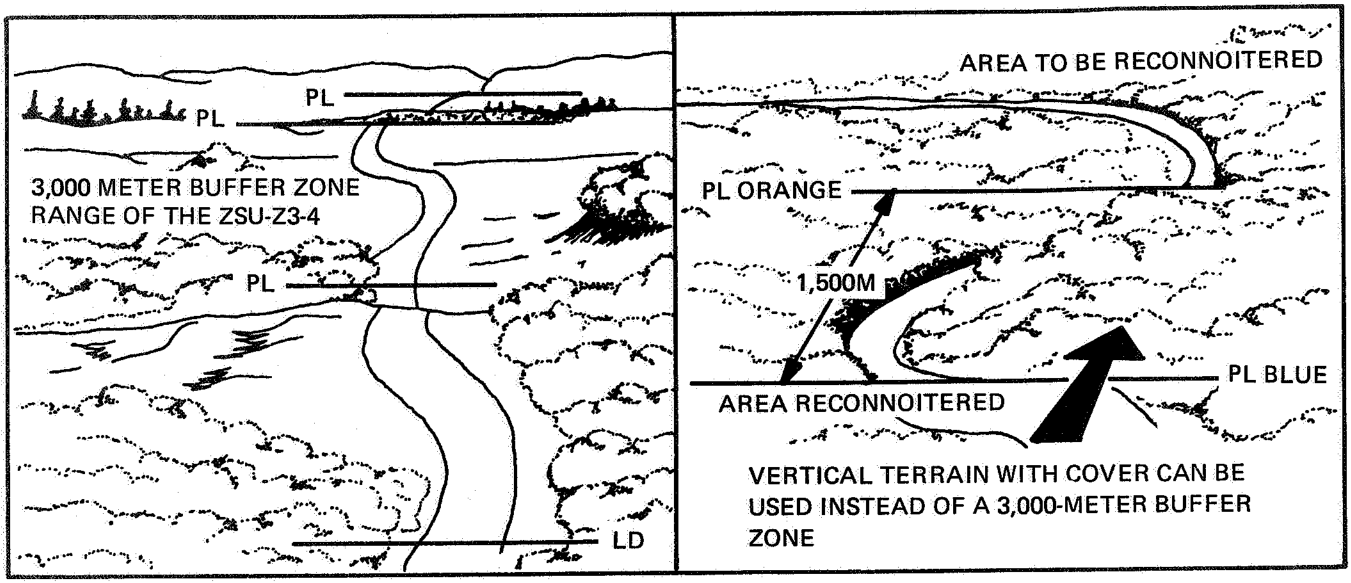


Figure 9-3. Route Reconnaissance

Features such as roads, rivers, and ridgelines are suitable for these boundaries. The area to be reconnoitered is *defined by lateral boundaries, a line of departure (LD), and an objective.* The objective provides a termination point for the mission; it may or may not be occupied by the enemy. A phaseline (PL) may also be used as a termination point.

9.3.2.3 Size of Area. Factors which determine the size of the area include:

1. Surface vegetation
2. Number of critical terrain features within the zone
3. Time available for the mission
4. Air-to-ground visibility
5. Anticipated enemy action
6. Number of reconnaissance elements available.

9.3.2.4 Division of Area Into Sectors. A large zone may be divided into several sectors, with an attack helicopter assigned to each sector. A series of air sweeps in S-turn patterns or along a rectangular course are normal for reconnaissance of a large zone. A narrow area may be reconnoitered in the same manner as a route reconnaissance. Areas that cannot be verified from the air should be checked by ground reconnaissance. Each area is reconnoitered in a systematic manner, starting with the LD. The terrain and width of the area determine how a reconnaissance is conducted. There are essentially two methods of area division. An area can be divided *vertically* into flight zones. This is appropriate when more than one section is deployed abreast and the zone is relatively wide. If the zone is very narrow, only one section may be used. The area may be divided *horizontally* into subzones by use of the phaselines (PL). This helps ensure that the enemy force is not inadvertently bypassed (Figure 9-4).

9.3.2.5 Formations and Techniques. Formations and techniques for searching an area vary with the size, shape, and nature of the area, as well as time available and the

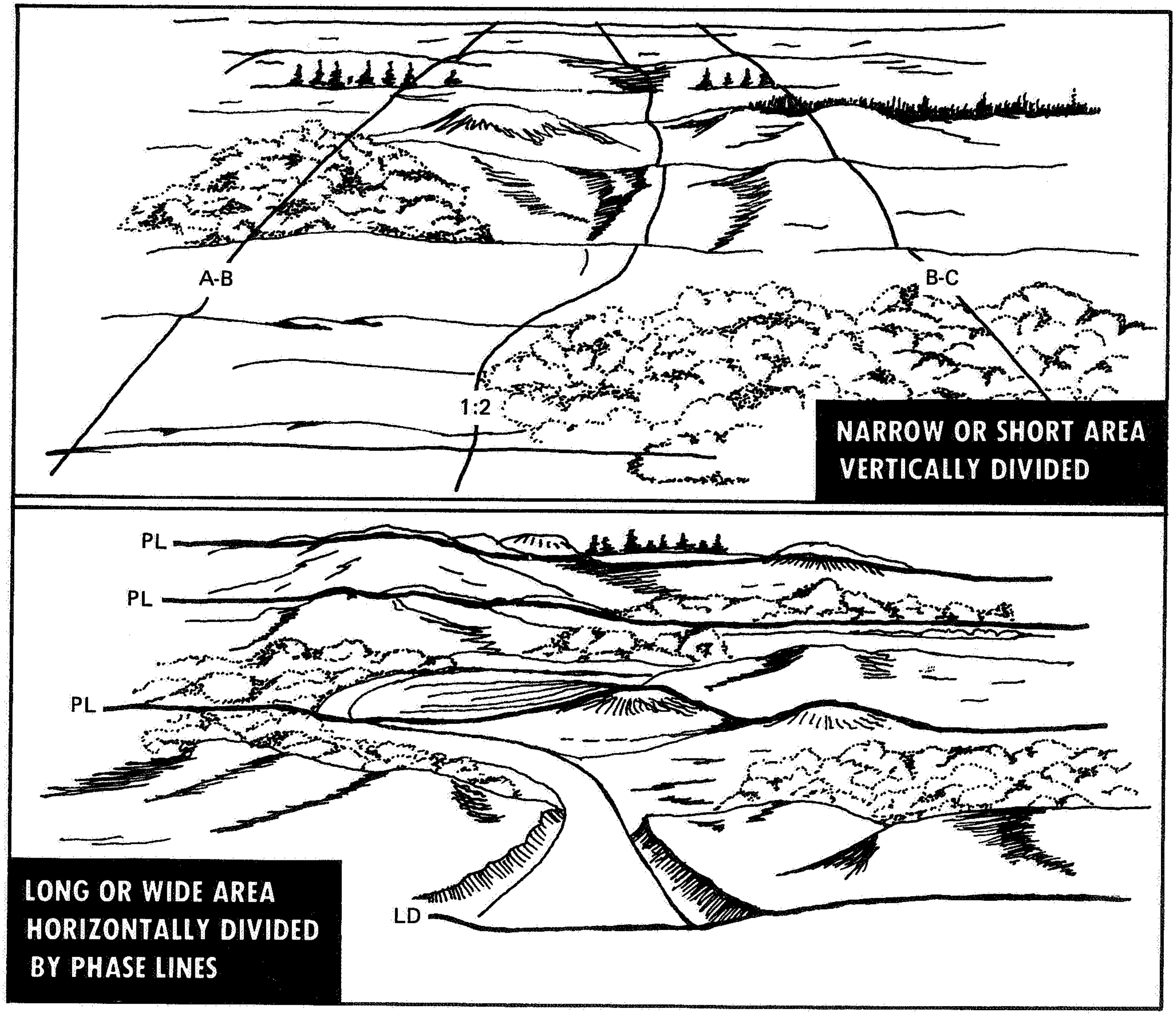

A-B
B-C
1:2
NARROW OR SHORT AREA VERTICALLY DIVIDED
PL
PL
PL
LD
LONG OR WIDE AREA HORIZONTALLY DIVIDED BY PHASE LINES

Figure 9-4. Division of Area Into Sectors

METT factors. The area reconnaissance must be accomplished in a rapid manner that will preclude enemy movement from an unreconnoitered area into an area previously searched and declared clear. Reliable communication and close coordination arrangements are applicable to this operation.

9.3.2.6 Premission Planning. On receipt of the mission, the flight leader and/or individual pilot should conduct a detailed map reconnaissance to be thoroughly familiar with the assigned area.

9.3.2.6.1 Map Reconnaissance. The flight leader/individual pilot tentatively decides what features, either terrain or manmade, dominate the area or are likely to hide enemy units. Area reconnaissance is a detailed reconnaissance; therefore, check all trails for recent use, all bridges for condition, location, demolition, and, if possible, classify them and closely examine all fording sites. Check all hilltops and dominating manmade features (water towers and tall buildings) for OPs and densely wooded areas for stay-behind or ambush units.

In summary, prior to taking off, pick out numerous significant checkpoints to be examined, then select a *tentative* route between them, utilizing terrain and vegetation to conceal your movement.

Designate checkpoints within the flight to aid in the movement of helicopter and in controlling movements within the team. The flight leader may also assign intermediate phaselines to assist in control of movement within his team.

9.3.2.6.2 Enemy Situation. Analyze the known enemy situation (threat), mission, safety, time available, and determine mode of terrain flight (low level, contour, or NOE).

After analyzing the enemy situation, select the type of movement to be utilized.

9.3.2.6.3 Frequencies. The flight leader should confirm radio frequencies and call signs with all pilots and ensure that all personnel know the mission and how it will be accomplished.

The flight leader should ensure that he knows the frequencies and call signs of any supporting arms which may be available.

9.3.2.6.4 Artillery Support. Arrange for several *preplanned targets* throughout the area. Normally, these would be placed on easily identifiable terrain features from which rapid shifts could be made onto targets of opportunity. If there are any known or suspected enemy positions, coordinate these locations in advance with artillery.

9.3.2.7 Mission Conduct. Conduct proper mode of terrain flight to the line of departure (LD), cross at the designated time and correct MEZ penetration poiint. Fly the mission on either the predetermined route or change the route as required due to the situation (enemy, lack of cover, or concealment).

9.3.2.7.1 Reports. Report all threat forces, *evidence* of threat forces, or *lack* of threat forces, route conditions, and other information requested.

Note

> Report what you see; i.e., "THREE T-62 TANKS," not "ONE TANK PLATOON." Normally, this information is reported immediately by radio.

9.3.2.7.2 FARP. If a team must be refueled or rearmed, it should go through relief on station.

9.3.2.7.3 Actions on Contact. If enemy contact is made, go through the standard actions on contact.

1. Deploy to cover (employ suppressive fire if necessary and available).

2. Report.

3. Maintain observation.

4. Develop the situation.

Depending upon several factors to include unit SOP, situation, and ability to communicate, you may not report the sighting prior to engaging it. In some situations, you may be required to bypass the target and not engage it at all. *When* and *whether or not* to engage depends on the situation which is influenced by the individual unit's SOP and the mission. Normally, the order to bypass will come from the squadron or higher. Maintain contact (surveillance) until ground units arrive in the area and a handoff is coordinated.

If first visual sighting or contact results in a good target such as a concentration of tanks, men, or vehicles, employ artillery and/or close air support while attack or ground elements are en route.

9.3.3 Point Reconnaissance. Point reconnaissance is used when intelligence is required about a specific point in the operating area. A point reconnaissance mission is assigned when the commander desires information on a town, ridgeline, woods, or other features that may be critical to the operation. The specific point to be reconnoitered is *designated by use of a boundary line completely enclosing the point.* With the exception of movement to and from the area, a point reconnaissance is conducted in the same manner as an area reconnaissance. The town, road junction, and so forth, *and controlling terrain* must be thoroughly reconnoitered. An air unit may perform a point reconnaissance forward of friendly lines when the situation is fluid or an open or lightly defended flank exists. The depth of a point reconnaissance behind enemy lines should normally be limited by the range of supporting artillery, or the availability of close air support. Close air support aircraft can be used to extend the depth of the reconnaissance by providing constant air cover. The purpose of this air cover is twofold: air defense and immediate suppressive fire.

A flight leader or individual leader or individual pilot assigned a point reconnaissance mission studies the factors of METT. Emphasis normally is placed on reaching the area quickly. Enemy situations encountered en route are developed only enough to ensure that reconnoitering elements can bypass and continue to the reconnaissance objective. Different corridors are used for the return flight to make it more difficult for the enemy to ambush returning aircraft. Flight corridors to and from the area are selected after an analysis of the enemy situation and terrain. Corridors are selected to:

1. Avoid known or suspected enemy locations.

2. Use available cover and concealment.

3. Permit reaching the area quickly.

Flight to the area is accomplished using terrain flight techniques. Enemy forces encountered en route are reported, and if possible, bypassed. Point reconnaissance mission must be completed rapidly. Passage of friendly lines must be carefully coordinated.

9.3.3.1 Formations and Techniques. The best formation to be used is combat spread which is oriented 90° from the line of advance where the enemy threat exists.

The lateral separation of the aircraft should be at least 500 feet and sufficient to prevent the mutual engagement of both aircraft by the same hostile fire. It should place the wingman close enough to the line of advance to allow him observation and to allow his ordnance to be effectively employed in support of the lead aircraft.

The altitude will be dictated by the threat.

Sightings of enemy activity should be reported as directed by the unit requesting the reconnaissance.

Maximum use of the secure area below the flight should be used if hostile fire is received or an immediate egress from the area is required.

When assigned a point or points of reconnaissance, the flight should also be briefed on the specific type of information that will be required. Points assigned for reconnaissance are normally prospective that may be attacked at a later time.

The route taken to the area and the formation to be used will be selected after evaluating the factors of METT.

9.3.3.2 LZ Reconnaissance. Selecting LZs for the lift elements requires that you gather as much information in as little time as possible. Normally, you will be sending the information by radio to an en route lift formation which is expecting confirmation of a certain LZ. Because of the tactical situation or the need for security, time may be a factor. Therefore, you must be able to collect the desired information rapidly while flying over the area only once or twice or observing the LZ from a distance. This goal can be reached only through constant practice and until the maximum amount of detail can be obtained in progressively shorter periods of time. (Procedures for selecting sites and zones to be used as pickup areas, landing zones, and tactical heliports or airfields are the same.) Considerations fall into three categories.

9.3.3.2.1 Tactical Considerations

a. Mission. The most important consideration when selecting a landing zone is the ability to accomplish the mission from or to that location.

b. Location. In order to reduce the fatigue factor for troops, any landing zone selected should be close to the unit or objective it is intended to support.

c. Security. Although security requirements vary, depending on the general location and purpose, aviation units must depend to a great extent on the supported unit for their active security. Landing zones are usually unsecured.

9.3.3.2.2 Technical Considerations. Technical considerations increase in significance as the landing zone becomes more complex. Some of the considerations are as follows:

a. Size of Landing Point. As a guide, a helicopter requires a relatively level, cleared, circular area at least 30 to 75 meters in diameter for landing, depending upon the type of helicopter. The area around the landing point must be cleared of all trees, brush, stumps, or other obstacles that could cause main or tail rotor blade strikes or damage to the underside of the helicopter. Generally speaking, a helicopter will require more usable landing area at night than during the day.

b. Number of Helicopter Used. An important factor is the number of helicopters required to land simultaneously at one location to accomplish the mission. It may be necessary to provide an additional landing site nearby or to land aircraft in successive flight at the same time.

c. Landing Formation. Planned landing formation may require modification to allow helicopters to land in restricted areas.

d. Surface Conditions. Surface conditions must be firm enough to prevent helicopters from bogging down, creating excessive dust, or blowing snow. Area should be as free as possible of loose debris.

e. Ground Slope. Normally, if the ground slope is greater than 8°, helicopters cannot land safely. It is possible, however, for helicopters to terminate at a hover over ground slopes greater than 8° to load or unload personnel or supplies.

Note

If AH-1 aircraft will be using the LZ, the ground slope must be less than 5°.

f. Approach/Departure Directions. When deciding approach/departure directions, primary consideration will be the tactical situation. Wind direction, obstacle clearance and landing area should be considered unless a single approach direction is dictated. Landing and take-offs with a crosswind or tailwind should be carefully considered and understood by the aircrew prior to commitment.

g. Loads. Fully loaded helicopters require a larger landing area and a better approach/departure route than empty or lightly loaded ones.

h. Obstacles. Approach or departure ends of landing zones should be free of tall trees, telephone or power lines, or similar obstructions that may interfere with the helicopter's landing zones (i.e., rocks, stumps, holes) that cannot be eliminated must be clearly marked or briefed to all pilots.

9.3.3.2.3 Meteorological Conditions. Prevailing meteorological conditions must be evaluated, to include the following:

a. Ceiling. Consider cloud base in relation to field elevation of LZ.

b. Visibility. Consider effects of sun, possibility of ground fog.

c. Density Altitude. The density altitude is determined by altitude, temperature, and humidity. For planning purposes, as density altitude increases, the size of the landing zone must be increased proportionately. Generally speaking, high, hot, and humid conditions at a given landing zone will decrease the lift capabilities of helicopters using that zone.

d. Relative Winds. The ability to land or takeoff crosswind/downwind will vary depending on the direction and velocity of the relative wind and its influence on the aircraft's power margin (power available minus power required.)

WARNING

Aircraft with a small power margin may not be able to safely land or takeoff with a crosswind/tailwind component to the relative wind.

9.3.3.2.4 Landing Area Worksheet. A landing area reconnaissance should be recorded on a worksheet which provides the commander with a graphic illustration in addition to the tabulated information if requested.

9.3.4 Line Reconnaissance. Line reconnaissance is conducted to gather information from the areas that have a linear boundary and is conducted over an area that is secure, observing an area that has known or suspected enemy concentrations.

9.3.4.1 Use. The line reconnaissance should be used when paralleling either a beach line or the front lines.

CHAPTER 10

Night and All-Weather Operations

10.1 GENERAL

The attack helicopter will be required to provide the same type of support at night and in reduced weather conditions as it is required to provide during day VFR missions. To provide this support requires highly disciplined and well-trained crews who are aware of their capabilities and limitations. The principles that apply to other operations apply equally well to night and all-weather operations, but there are certain principles that require additional emphasis during these operations. All missions must be carefully prebriefed down to the finest detail so that all participating elements are aware of their responsibilities and to ensure that positive control is maintained at all times. The location of friendly troops must be carefully and clearly marked so that all members of the flight are aware of their positions. With the appliction of the proper precautions and principles, the conditions of darkness and reduced weather can, in many instances, be used to the advantage of the attack helicopter pilot.

10.2 NIGHT OPERATIONS PLANNING

The employment of night helicopterborne operations offers a means of achieving tactical surprise, of improving detection avoidance, and of countering those weapons which rely on visual acquisition of targets. However, the achievement of these results in a high-threat environment will continue to depend on the effective use of terrain masking to avoid detection. The proliferation of sophisticated air defense systems for detection and target acquisition plus the widespread introduction of night vision/night sighting devices, negate much of the tactical advantage gained from the concealment afforded by darkness for flight operations conducted at altitudes above the terrain mask.

At the present time, the primary limitation to executing night helicopter operations in a high-threat environment is a physiological one. That is, a pilot cannot see to conduct NOE or contour flight safely, nor can he locate an LZ and land without the aid of illumination. Under optimum conditions of natural illumination, terrain configuration, and visibility, low-level flight is feasible; however, LZ identification and landing approaches require the use of either LZ lighting or flare illumination.

Pending the development and acquisition of night vision devices to expand existing operational capabilities, the execution of night helicopterborne operations will depend on the use of the positive control techniques, flight procedures, and terminal lighting aids to provide navigational assistance, adequate terrain and obstacle clearance, aircraft and flight separation, and visual cues for landing. The following paragraphs provide specific information concerning the planning and employment considerations used in night helicopterborne operations.

10.2.1 Planning Considerations. The planning considerations described previously in this manual are applicable to night operations. Additionally, there are considerations which are unique to night operations. Generally, these considerations are concerned with the limitations imposed by the reduction in visual acuity, the necessity for positive aircraft control procedures, and the necessity for caution on the part of the pilots and troops which both characterize and complicate night operations.

A slower tempo of activity must be accepted in night operations. Smaller helicopter waves (preferably two aircraft) should be used, and the interval between waves should be increased to provide adequate separation between flights and to minimize congestion in the landing zone. Flight delays will be encountered due to the use of procedural air traffic control techniques and the problems inherent in conducting rendezvous, approaches, and landings at night. Troop and cargo loading and unloading operations tend to be slower and more complicated. Such delays should be anticiapted and time factors increased accordingly when plans and assault schedules are formulated. The end result of these factors is a slower buildup of combat power in the landing zone.

Detailed planning at all levels and thorough mission briefings are required to compensate for the restrictions and limitations inherent in night helicopter operations. Joint briefings should be conducted with representatives from each participating air and ground element in attendance. In addition to the briefing information described in Chapter 7, briefings for night operations shall provide detailed information concerning aircraft lighting, flight formations, landing zone lighting, flare illumination, flight control procedures, time/distance/altitude intervals and separations, and aircrew coordination.

10.2.2 Training. The proficiency of the individual pilot in conducting tactical operations at night depends, in part, on his understanding of the basic principles of night vision and his ability to correctly apply night vision techniques and flight instrument information to accurately interpret the position and performance of his helicopter in relation to the terrain and surroundings. Appendix F provides instructional information to assist the pilot in acquiring these skills and for use in unit level training programs.

The key element to improving pilot and unit night tactical proficiency is unit level training. Such training should focus on each operational phase (planning, support, control, and execution) and, to maximize the training dividend, should concentrate exclusively on night operations until the desired level of unit tactical proficiency is achieved. The training program should be realistic and should be structured to progress from simple tasks and mission to complicated tactical problems to develop sklls and create confidence in individual abilities, crewmember coordination, unit capabilities, and the control procedures and techniques used to ensure safe operations. Training should be conducted under both natural and artificial lighting conditions with escort and supporting arms support.

The final stage of training for a planned operation should be a full-scale rehearsal to test and refine the concept of operations, scheme of maneuver, and operational procedures.

10.2.3 Planning. During the planning phase of a helicopterborne operation, the mission commander should maintain close coordination with the landing force commander. He should have a thorough understanding of the commander's concept of the operation. This information is needed to assist in making decisions which may be required during the conduct of the operation.

10.2.4 Enemy Threat. Before selecting the route to be flown, information which identifies the enemy's air defense capabilities must be known. The air defense threat will dictate the type of low-level operation (e.g., low-level, contour, NOE) which must be flown to avoid detection by the enemy. A safe altitude will vary according to the type terrain and the distance the weaponry is from the aircraft. By conducting a terrain profile, a safe altitude can be determined. Knowing these limitations, the helicopter can be flown at the highest altitude which affords assurance of safety as it passes from the rear area forward to the FEBA. This procedure relieves the aviator of the stress and fatigue that he would have experienced had he flown the entire route NOE.

To ensure that the flight route will be planned to avoid these positions, known enemy air defense artillery (ADA) positions should be plotted on the map. Also, enemy ground forces should be identified and, when possible, overflight should be avoided. Before conducting a helicopterborne operation, consideration should be given to the enemy threat which exists in the landing zone (LZ). Intelligence reports may indicate a sufficient number of profitable targets in and around the landing zones; however, the effect gained by an artillery preparation may not offset the loss of surprise. Because darkness increases the element of surprise, detection of the helicopter is difficult at night. Artillery preparations are normally omitted from night helicopterborne assaults, but they are preplanned on and around the LZ for on-call use. Smoke can be used effectively at night and should be considered when conducting night helicopterborne operations.

Before conducting a night terrain flight over enemy positions, aircrews should be advised of the enemy's passive defense capabilities. The enemy's use of searchlights to blind the pilot or the positioning of obstacles (e.g., blimps, cables) along likely low-level routes may require the mission commander to adjust his scheme of maneuver. Also, it alerts the aircrews to the probability of encountering these defenses and assists in planning evasive maneuvers to counter the threat.

10.2.5 Terrain Evaluation and Route Selection. After conducting a mission analysis and evaluating the enemy's capability, a map reconnaissance of the area of operation should be conducted. This study would include, but not be limited to, the following factors:

To ensure masking of the helicopters, select a route where it has been determined that higher terrain lies between the route and the known enemy position. It is desirable to mask the helicopter from both electronic and optical weaponry. Where terrain features or the location of enemy weapons restricts masking to both systems simultaneously, the helicopter should be masked against the electronic system. This situation occurs where the enemy has strategically located his optical weapons to fill gaps where radars cannot detect low-flying aircraft. Visual detection at night will be difficult for optical guncrews even when the helicopter is not masked, whereas electronic detection is not affected at night. Also, the helicopter being exposed for a short duration further detracts from the enemy's optical guncrews ability to effectively engage an airborne target.

To assist in ease of navigation at night, consideration should be given to selecting routes which have recognizable features. Primary emphasis should be placed on identification of terrain features rather than manmade features; however, manmade features which retain their identity provide good landmarks. Terrain profile may allow masking of the helicopter without regard to vegetation (e.g., masking by a hill). Where this condition exists, routes which facilitate ease of navigation and permit flight at a higher altitude (e.g., contour) should be selected.

During the conduct of the map reconnaissance, consideration should be given to selecting both the approach and separate departure routes. This procedures is necessary to protect against an enemy tactic to emplace weapons along the approach route in anticipation that the helicopter will return along the same route. Final route selection should be based on the following factors:

1. Mission
2. Masking capability
3. Recognizable terrain features
4. Enemy situation
5. Effects of moon altitude
6. Effects of weather.

After selecting the primary approach and departure routes, one or more alternate routes should be selected. Additional routes are selected to provide the pilot with alternate courses to fly in the event the tactical situation negates use of the primary route. Criteria for selection is the same as for the primary routes. Each route should be identified by a code word and all aircrews participating in the operation should have the routes plotted on their maps.

During the map reconnaissance, obstructions (e.g., power lines, antennas) which are identified should be marked on the map. Intelligence sources may reveal recent construction of obstacles. Photo analysis will provide the most accurate and up-to-date status of obstructions along the flightpath.

10.2.6 Map and Aerial Photo Preparation. Of the various types of maps available for the planning and execution of night operations, the joint operations graphic (JOG) (1:250,000) will best serve as the primary map for the en route portion of the mission. A current VFR sectional should be used to update the JOG for hazards such as power lines, large towers, beacons, airports, towns, etc., and to ascertain the current variation. A tactical map (1:50,000) can be used to study and interpret areas of the JOG which may be vague.

For the objective portion of the mission, a tactical map should be used. It should be of sufficient size to cover an area at least 5 nm from the objective area. (The transition from the JOG to the tactical map can be disorienting, because the aircraft appears to be moving over this large-scale map much more quickly.) (See NWP-55-9-ASH, Vol. I, Chapter 13).

10.2.6.1 Marking Maps. Certain essential items must be placed on the face of the map.

10.2.6.1.1 Control Point. A control point (CP) is an easily identifiable point and provides positive control and coordination during an air movement. These points define the intended flight route. CPs may be marked with a circle around the feature.

10.2.6.1.2 Course Lines. A line should be drawn to denote the desired ground track. Course lines should be indicated as sharp, clear lines on the map.

10.2.6.1.3 Magnetic Headings. Magnetic headings are indicated along the course line for each leg. Grid-magnetic angle must be applied to the course to obtain a magnetic heading.

10.2.6.1.4 Mileage Tic Marks. Mileage tic marks are marks drawn to bisect the course line at 2-mile intervals. These marks assist in dead reckoning navigation when identifiable terrain features are not available.

10.2.6.1.5 Checkpoint. A checkpoint is a landmark that is selected along or adjacent to the flight route and used to fix an aircraft's position. A checkpoint must be a unique feature or group of features in a given area.

10.2.6.1.6 Miscellaneous. Other items of information that may be placed on the map face are distances, barriers, and obstacles. However, this informaion may clutter the map and serve only to confuse the aviator.

10.2.6.2 Aerial Photo. An aerial photo supplements the terrain information found on a tactical map. A detailed study of an aerial photo may reveal terrain features which will provide a good checkpoint that could not be identified from the map. Because the photo is current, information relating to manmade features will be more accurate. Changes such as a new road, additional cultivated land, or a new bridge may confuse a pilot; however, prior knowledge of these changes will significantly aid in navigation. Obstacles, whether natural or passive defense measures, can be detected and will assist in route selection. The aerial photo is not normally used as the primary reference for navigation during the conduct of the flight. Information acquired from the photo which will assist in navigation or obstacle recognition should be transferred to the map. In a situation where the accuracy of the map detracts from the aviators ability to navigate, the aerial photo may be used as the primary reference for navigation.

10.2.6.3 Folding Map. The need for detailed information requires that a large-scale map (1:50,000) be used for navigating at night. Because of its bulky size, it must be folded. A technique must be developed which will allow the navigator to follow the helicopter's position along the ground while transferring from one fold to another.

10.2.7 Special Equipment. During the initial planning phase of a night tactical operation, the requirement for special equipment should be identified. A request for this equipment should be forwarded to the appropriate channel to ensure that it is available and operational on the date required. Based on the mission and the ambient light condition, one or more of the following items may be required for a night terrain flight:

1. Helicopter (night configuration)
2. Night vision device(s)
3. Red-lensed goggles
4. Special night map
5. Flashlight (NVG compatible).

10.2.8 Meteorological Conditions

10.2.8.1 Forecasted Weather. The decision to perform a night terrain flight should be based on the existing and forecasted meteorological conditions. Although forecasted weather predictions do not always materialize, the risk of encountering adverse conditions during the conduct of the mission precludes night operations requiring terrain flight into forecasted IMC. During combat operations, weather data which will assist in predicting weather conditions for the objective area may be denied friendly forces. When this occurs, weather predictions become less reliable; however, climatic records give indicators from which long-range trends can be determined. Also, weather satellite photos provide a good indication of existing cloud coverage over enemy terrain.

10.2.8.2 Existing Weather. Existing weather conditions allow for immediate evaluation of the effects upon the ambient light condition. When cloud coverage (e.g. overcast) exists, hemispherical illumination may be reduced to total darkness. Operations may be conducted during conditions less than overcast; however, with use of night vision devices, the degree of risk is decreased. Missions performed during these conditions with the unaided eye should be conducted when the moon is at its zenith. Restrictions to visibility are the most serious meteorological conditions that are experienced at night. Both the unaided eye and night vision devices are affected by visibility restrictions (e.g., fog, haze, smoke). These conditions must be considered as part of premission planning to determine their effects on the conduct of the night operation.

10.2.9 Rehearsal. During the conduct of night terrain flight, the aircrew must function as a team. To improve the effectiveness of the team, each member must improve his knowledge and practice in the art of communication and standardize his use of words and visual signals. To avoid misunderstandings in the cockpit during the conduct of the mission, crewmembers should verbally rehearse the flight while on the ground using the map to describe the route as it will be flown. This procedure should be repeated as many times as necessary until each crewmember is thoroughly familiar with the route to be flown and the terminology that will be used to describe the terrain features. In addition, crewmembers must be familiar with the airborne responsibilities discussed in paragraph 10.2.12 prior to the conduct of the mission.

10.2.10 Navigation

10.2.10.1 Radio Navigation Aids. Navigation aids (e.g., tacan, ADF, radar) which require line of sight propagation become unreliable when flight is conducted at terrain flight altitudes. The low frequency nondirectional radio beacon provides reception for the greatest distance; however, information displayed on the ADF indicator is inaccurate and can only be used for orientation by the pilot. The FM homing capability of the ARC-114/134 radio set provides an accurate means of radio navigation for short distances to locate ground units which transmit an FM radio signal. During extraction and succeeding insertions, FM homing can be used effectively; however, initial insertions must be accomplished without the aid of FM homing.

10.2.10.2 Dead Reckoning. Due to the continuous heading and airspeed changes, dead reckoning navigation is difficult, if not impossible, to accomplish when conducting night terrain flight. Where recognizable terrain features are not available, time and heading must be flown between two points. Estimations (by the pilot's senses) of distances and times flown are misleading and normally result in disorientation. To prevent overflight of the checkpoints, accurate estimates using dead reckoning procedures, the helicopter must be flown in adherence to the heading and airspeed at which the estimates are computed.

10.2.10.3 Pilotage. Because a night terrain flight requires constant changes in heading and airspeed, the primary means of navigation is pilotage. Each crewmember should memorize the layout of the flight route and prominent checkpoints. As the helicopter is flown along the route, a continuous comparison is made between what is seen on the ground and what is represented on the map. It is essential that the navigator/copilot knows the location of the helicopter at all times. Accuracy of navigation requires that the helicopter be flown within 100 meters of the center of the preselected course. To achieve this degree of accuracy at night, airpseed must be reduced.

10.2.11 Disorientation Procedures. During conditions of low ambient light, visual range is reduced. This condition restricts the pilot's ability to positively identify a recognizable terrain feature close in to the helicopter by reference to a prominent terrain feature at a greater distance. As a result, a tendency is to misidentify terrain features because they resemble what is seen on the map. This error may not be recognized until the helicopter has flown off course a significant distance. When it becomes apparent that disorientation has occurred, the pilot should attempt to reorient himself. If this cannot be accomplished, he should return to the last known position. Further flight in the general direction of the proposed route seledom results in the reorientation and should not be attempted. Upon reorientation, the pilot must decide if the loss in time has jeopardized the successful accomplishment of the mission or if the flight should be continued.

10.2.12 Crew Responsibilities. Prior to the execution of a night mission requiring terrain flight, each crewmember should know and understand the duties which must be performed while in flight. The ability of the aircrew to perform as an effective team is dependent on the amount of individual and crew training that has been received. Preplanning and ground rehearsal will also help improve the coordination that is essential during the conduct of the mission. The responsibilities for each crewmember are as follows:

10.2.12.1 Pilot. The pilot's primary responsibility is to maneuver the helicopter with smooth and coordinated control movements to ensure obstacle clearance. To accomplish this, he must be free at all times to observe outside the cockpit. He assists in terrain recognition by pointing out significant terrain features and responds to all outside radio calls. Changes in heading are in response to the navigators command and to avoid terrain obstacles. The pilot is also responsible for monitoring the mechanical function of the helicopter and executing emergency procedures in the event of a system failure.

10.2.12.2 Navigator/Copilot. The primary responsibility of the navigator/copilot is to navigate. To ensure orientation at all times, he gives the pilot commands as to headings to be flown. In addition to this formation, he advises the pilot of the average ground elevation over which the flight is being flown, obstacles that may be encountered along the flightpath, time to the next checkpoint, and he verbally describes the next checkpoint so that the pilot can assist in identifying it. The navigator/copilot assists the pilot in monitoring the mechanical function and the flight attitude of the helicopter. If an unsafe condition arises, he will advise the pilot or take control of the helicopter when required.

10.2.13 Dark Adaptation. Those flight operations which are conducted at night from one well-lighted area to another over routes which afford little or no opportunity to protect and preserve night vision frequently result in complacence and dubious attitudes on the part of aircrew memebers as to the importance of dark adaptation. Pilots should familiarize themselves with visual problems unique to night flying and navigation and the suggested solutions or night flying techniques listed in Appendix F. Most of these techniques are applicable both with and without night vision devices. In both instances there are valid requirements for dark adaptation for aircrew members and for the use of light discipline procedures.

Commanders shall ensure that operating procedures require aircrew members to achieve dark adaptation prior to night tactical operations and, further, that the support facilities and procedures used are designed to preserve and protect aircrew member night vision. The use of red lens goggles, the enforcement of light discipline procedures, and the outfitting of briefing, alert, maintenance support, and flight line facilities with red lighting are examples of the steps that can be taken to facilitate dark adaptation by aircrew members.

10.2.14 Aircraft Preparation. Ensuring that the aircraft is properly prepared for a particular mission is the responsibility of both the maintenance department and the individual pilot. Certain preparations can be undertaken by the maintenance department. The following is a list of times for consideration but is not all inclusive:

1. To ensure that all illumination is standard, the interior lights should be checked to see that each one functions properly.

2. Gages should be cleaned so as to be easily read during period when low-intensity illumination is being used.

3. The instrument panel and all consoles should be kept clean so all etched lettering will be readable.

4. The wind screens should be cleaned and free of scratches.

5. Consideration should be given to putting transluscent tape over lights that can cause a distracting glare during flight (i.e., master caution — rad alt low light, etc.).

CAUTION

> Care should be taken so that intensity remains sufficient for warning during emergencies.

6. Surfaces that are normally painted black should be retouched if scrapped or scratched as scratches will increase the amount of reflected light inside the cockpit.

10.2.15 Illumination Support. A decision shall be made during the planning phase of an operation whether to rely on natural lighting or to use artificial illumination to provide the level of ambient light necessary for mission accomplishment. Regardless of which concept of operation is chosen, the use of artificial illumination shall be planned and provisions shall be made for such support as a contingency for all night tactical missions to provide an on-call illumination capability for emergency situations.

10.2.15.1 Advantages and Disadvantages. Night operations which rely on natural lighting should realize the following advantages:

1. The element of surprise is maintained longer.

2. Night vision capabilities are maximized and conserved.

3. Helicopters are difficult to acquire, track, and engage by visual means.

4. Ground fire is easy to see.

The following disadvantages accrue when a mission is conducted exclusively with natural lighting:

1. Navigation is difficult due to the inability to discriminate terrain.

2. Landing zones are more difficult to identify.

3. Depth perception is greatly reduced.

4. The potential for midair collision is increased in multihelicopter operations.

5. Escort support capabilities are restricted.

The advantages of employing artificial lighting are:

1. Permits navigation by reference to the terrain.

2. Aids in landing zone identification.

3. Provides a visual horizon.

4. Permits see and avoid procedures for maintaining safe separation of aircraft and flights.

5. Permits the use of daylight operating procedures, flight techniques, and escort support procedures.

The disadvantages associated with the use of artificial illumination are:

1. The element of surprise is lost.

2. Dark adaptation is lost.

3. Facilitates enemy air-defense efforts.

4. Continuous illumination may be required for landing zone approach and departure operations.

5. Creates a hazard to helicopters from descending, unlighted parachute flares.

10.2.15.2 Method of Employment. Illumination may be employed in a variety of ways depending on the lighting effect desired. Close-in illumination may be used to produce ambient light levels in the vicinity of the landing zone which approximate daylight conditions. Offset illumination may be used at a distance to produce ambient light levels in the landing zone similar to twilight conditions. Offset illumination also provides a visible horizon and, depending on where it is employed, may have tactical utility as a means of deception while increasing the ambient light levels in the vicinity of the landing zone. Short duration illumination over designated geographic locations on a prearranged time schedule may be used to aid in a navigation.

As a general rule, illumination is most effective when it is positioned so as to provide the required level of ambient light in the landing zone, when it creates a visible horizon and when it is offset from the landing approach heading so as not to blind the pilot. Unless deception is the primary purpose, the extent and intensity of illumination should be limited to provide the minimum acceptable light level, rather than the maximum, to preclude any advantage which the enemy might realize.

WARNING

When parachute supported illumination devices are being used, care should be exercised to avoid collision with the devices after the flare has extinguished. Aircrew members shall be briefed to monitor flares so as to warn the pilot of potential collisions. Aircraft shall not fly directly beneath the flare pattern or in the predicted down wind path of the pattern. Expended parachute flares in the landing zone may become airborne in rotor wash and create a hazard.

10.2.16 Aerial Flares. Flare ship aircraft are the most effective, the most versatile, and the easiest to control means of providing illumination. Although several types of aircraft are capable of providing flareship support. It is generally used in a low-threat environment.

Cargo-type (C-130) aircraft with long endurance capabilities and large flare capacities should be employed only in low-threat environments. Close air support aircraft and attack helicopters are best suited for flareship support in a high-threat environment; one aircraft in each flight may be loaded with flares or each aircraft may have a split ordnance/flare load.

10.2.16.1 Types of Aerial Flares

10.2.16.1.1 Mk-45 Parachute Flare. The Mk-45 parachute flare can be carried and released by all aircraft.

1. Delivered via a SUU-44/A dispenser or loaded externally on MER/TER/PMBR bomb racks.
2. Capacity of SUU-44/A is eight flares which can *only* be launched in pairs.
3. Burn time — 210 seconds
4. Illumination — 2,000,000 candlepower
5. Rate of descent — 7 feet/second
6. Drift rate — 1.7 feet/second.

10.2.16.1.2 LUU-2 A/B, -B/B Parachute Flare. The LUU-2 parachute can be carried and released by all aircraft.

1. Delivery
   (a) LUU-2 A/B can be delivered via a SUU-44/A dispenser or loaded externally on MER/TER bomb racks.
   (b) LUU-2 B/B can be deliverd via a SUU-44/A dispenser or SUU-25 F/A dispenser or loaded externally on MER/TER bomb racks.
2. Capacity of the SUU-44/A and SUU-25 F/A dispensers is eight flares. Flares are launched in pairs from the SUU-44/A and singly from the SUU-25 F/A.
3. Burn time — LUU-2 A/B 300 seconds; LUU-2 B/B, 240 seconds

4. Illumination — LUU-2 A/B, 1,600,000 candlepower; LUU-2 B/B, 2,000,000 candlepower

5. Rate of descent — 8 feet/second for both flares.

10.2.16.1.3 M257 (2.75-Inch) Rocket Illumination Warhead. Can be delivered by all aircraft.

1. Delivery — 2.75-inch rocket

2. Burn time — 100 seconds

3. Standoff range — 3,000 to 3,472 meters (9,843 to 11,391 feet) depending on rocket motor used.

4. Illumination — 1,000,000 candlepower

5. Rate of descent — 13 feet/second

10.2.16.1.4 Mk-33 (5.00-Inch) Rocket Illumination Warhead. Can be delivered by all aircraft.

1. Delivery — 5.00-inch rocket

2. Burn time — 90 seconds

3. Illumination — 1,000,000 candlepower

4. Rate of descent — 18.5 feet/second

10.2.16.2 Aerial Flare Capabilities of Marine Aircraft. Maximum flare capabilities for various aircraft are as follows:

1. AH-1 J/T — four SUU-44/A or SUU-25 F/A dispensers with a total of 32 Mk-45/LUU-2 parachute flares: four LAU-10 rocket pods with 16 Mk-33 warheads; four LAU-61 rocket pods with 76 M257 warheads; four LAU-68 rocket pods with 28 M257 warheads.

2. OV-10A — five SUU-44/A or SUU-25 F/A dispensers with a total of 40 Mk-45/LUU-2 parachute flares; two PMBRs with a total of 12 Mk-45 flares. Rocket flare warhead capacity is the same as the AH-1 J/T.

3. OV-10D — seven SUU-44/A or SUU-25 F/A dispensers with a total of 56 Mk-45/LUU-2 parachute flares; four PMBRs with a total of 24 Mk-45 flares; six LAU-10 rocket pods with 24 Mk-33 warheads; six LAU-61 rocket pods with 114 M257 warheads; six LAU-68 rocket pods with 42 M257 warheads.

4. A-4 — six SUU-44/A or SUU-25 F/A dispensers with a total of 48 Mk-45/LUU-2 parachute flares; five MERs with a total of 30 Mk-45/LUU-2 flares; nine LAU-10 rocket pods with 36 Mk-33 warheads; nine LAU-61 rocket pods with 171 M257 warheads; nine LAU-68 rocket pods with 63 M257 warheads.

5. A-6 — four SUU-44/A or six SUU-25 F/A dispensers with a total of 32/48 Mk-45/LUU-2 parachute flares; five MERs with a total of 30 Mk-45/LUU-2 flares; ten LAU-10 rocket pods with 40 Mk-33 warheads; ten LAU-61 rocket pods with 190 M257 warheads; ten LAU-68 rocket pods with 70 M257 warheads.

6. AV-8 A/C — two SUU-44/A or SUU-25 F/A dispensers with a total of 16 Mk-45/LUU-2 parachute flares; four LAU-10 rocket pods with 16 Mk-33 warheads; four LAU-61 rocket pods with 76

M257 warheads; four LAU-68 rocket pods with 28 M257 warheads.

7. F-4 — four SUU-44/A or SUU-25 F/A dispensers with 32 Mk-45/LUU-2 parachute flares; three MERs with a total of 18 Mk-45/LUU-2 flares; fifteen LAU-10 rocket pods with 60 Mk-33 warheads; 13 LAU-61 rocket pods with 247 M257 warheads; 15 LAU-68 rocket pods with 105 M257 warheads.

8. F/A-18 — two MERs with a total of eight LUU-2 parachute flares; eight LAU-10 rocket pods with 32 Mk-33 warheads; 4 LAU-61 rocket pods with 76 M257 warheads; four LAU-68 rocket pods with 28 M257 warheads.

9. KC-130 R/F — internally carries 320 LUU-2/Mk-45 parachute flares that are crew launched. The KC-130R can fly 100 nm and loiter for 10 hours, while the KC-130F has the same range, but can only loiter for 7 hours.

10.2.16.3 Artillery and Naval Gunfire Flares. Artillery and naval gunfire are capable of providing illumination support. However, their use in other than preplanned missions will require a period of time for the adjustment of the flares to the desired position. Artillery and naval gunfire flares produce less light than aerial flares and require more flares for contintinous illumination due to their short burn time. Their major advantages are their availability in conditions of reduced weather when aerial flares cannot be used, their capability to provide illumination for long periods of time, and that their employment is not affected by enemy air defense capabilities. Because of the latter advantage and the need to conserve aviation assets, in a high-threat environment, artillery and naval gunfire should be used as the primary means of illumination for missions within their range capabilities.

10.2.17 Flare Capabilities of Artillery and Mortars

TYPE	RANGE	BURN TIME (SEC)	DIA. OF AREA (METERS)
81-MM Mortar	3300 Meters	75	1100
4.2 Mortar	5500 Meters	90	1500
105-mm Howitzer	11,000	60	1000
155-mm Howitzer	14,600	60	1000
155-mm Howitzer (SP)	14,600	150	2000

Note

Continuous illumination is two rounds per minute.

10.2.18 Landing Zone Lighting. Some type of lighting aid should be used to assist the pilot in locating and identifying the landing zone and accomplishing a landing at night. Lighting aids such as sophisticated terminal guidance systems, expeditionary lights, flare illumination, and field expedients (e.g., vehicle lights, flash lights, strobe lights, bonfires, smudge pots, lights with infrared filters for use with NVGs) have been used successfully. Regardless of the means employed, effective landing zone lighting should:

1. Be visible to the pilot.

2. Identify an area free of obstacles which is safe for hovering and landing operations.

3. Employ three or more lights at least 15 feet apart to prevent autokinetic illusions.

4. Provide orientation along obstacle-free approach/takeoff corridors.

10.2.19 Night Helicopterborne Assault. The launching of a helicopterborne force at night for other than preplanned assaults will normally focus on a friendly position in contact or a reconnaissance team in contact. Exact procedures for these missions will be addressed in later sections. However, the following considerations should be explored:

1. The landing zones utilized must be larger and more recognizable. It will also be necessary to utilize smaller helicopter waves with greater time intervals between waves. Time required for loading, rendezvous, approach, landing and unloading will be increased.

2. Considerations governing the employment of helicopters at night include the availability of prominent landmarks easily recognizable under conditions of limited visibility or the familiarity of the pilots with the area. In the timing of the operations, consideration should be given to utilization of periods of sufficient visibility for the initial approach and landing. Once the landing zone is secured, navigational aids can be installed to facilitate continued operations.

3. The use of electronic or visual aids to navigation is a requirement for successful night operations, except in rare cases where a combination of good visibility and easily recognizable terrain features exist. Greater emphasis is placed on terrain characteristics when selecting landing zones, and helicopter lanes are as direct as possible for ease in navigation. Initial terminal guidance teams install the necessary navigational aids to permit landing of the main body. It must be remembered that helicopters will have to use external lights when flying in formation at night.

4. It is desirable to employ helicopters under cover of darkness to position troops in attack positions near easily recognizable terrain features. Once the objective has been secured and the necessary landing zones cleared and marked, helicopters may be employed to move reserves and supporting weapons directly to the objective.

5. A slower rate of activity must be accepted in night operations. Fewer helicopter landing points may be used, and loading and unloading times are increased. Only dim or red-tinted lights may be used in the vicinity of the loading and landing zones. Bright lights destroy night visual adaptation and may disclose activity to the enemy.

6. The landing zone (site) is organized similarly as for daytime operations, except that landing sites (point) must be marked with lights by initial terminal guidance teams.

7. When LZ lighting is not available or not desired, constant flare illumination is mandatory during the helicopter approach/retirement phase. This is required to allow full utilization of escorting gunships and to ensure safe clearance of obstacles during approach and departure.

8. All flights should be controlled by an HC(A) who will define orbit points, direction of orbit, altitude separation, and approach/retirement routes.

10.2.20 Night Medevac. Night medevac missions are perhaps the most demanding of helicopters missions, particularly during foul weather. The transport commander is not only pressured by expeditious mission accomplishment to save lives but with enemy hostilities as well. Only emergency medevac missions will be conducted at night. The following considerations apply in addition to those specified in the Medevac Section.

1. Positioning of the aircraft in the flight is critical. Normally, they should be positioned in such a manner that represents the

optimum between mutual protection from hostile fire and ability to efficiently detect and avoid IFR conditions.

2. There are two accepted means for recognizing and approaching the landing zone; each has its advantages and disadvantages. First, the medevac aircraft may elect to locate the zone and land through use of stobe lights only. With running lights out, this affords the landing helicopter some protection against hostile fire, but increases the possibility of a landing mishap drastically. It also severely limits the gunships capability to deliver suppressive fire because of difficulty in target acquisition. The other means of accomplishing the medevac is to use illumination and strobe lights. Illumination allows the gunships to provide the same fire suppression and smoke screen capability as during daylight operations. However, the illumination also exposes the transport helicopter to the enemy. Therefore, the type approach utilized should be weighed against pilot proficiency, enemy situation, and existing terrain features.

3. An additional problem associated with night medevac is maintaining adequate night vision. Since the medevac alert is normally stood in a central location with a fifteen minute airborne capability, it is imperative that proper lighting in the alert facility be provided. Utilization of red lights is the best means of providing some illumination in the facility and at the same time preserve the pilots night vision. Therefore, the senior officer present must ensure that such illumination is used.

4. Pilots must also be aware of the navigational aids available for locating medevac positions, aiding in navigation, and recovery of aircraft when inadvertent IFR is encountered.

10.2.21 Target Illumination Procedures. Whether the attack helicopter or some other source is to provide the illumination, the flares should be positioned where they will produce the optimum results. They should be placed where they will not only illuminate the target or the landing zone but also provide an artificial horizon where required. To achieve the proper effects they are most effective when offset from either the attack run-in heading or the final direction of approach of the transport helicopters.

WARNING

When working with parachute supported illumination devices, extreme care should be taken to avoid the parachutes after the flare has burned out.

CAUTION

Care should be taken to avoid having flares, either burning or expended, in the landing zone.

10.2.22 Attack Patterns. The attack pattern most commonly used at night is the race track. (Figure 10-1.) Because of the degree of control required for more advanced or intricate patterns, they are not normally suitable for night attacks. The race track pattern will normally be extended to allow sufficient time to ensure that preceding helicopters are well clear of the target area prior to initiation of the attack run.

10.2.23 Target Acquisition and Marking. The methods of marking and acquiring targets and landing zones are many and varied. The most common of these methods are flashlights, tracer fire, strobe lights, incendiary grenades, white phosphorus, and/or any burnable material. Artillery and mortar may also be used to mark the target. Once the target zone is located, the pilot should select a prominent terrain feature in the vicinity so that the target can be reacquired without the need for additional markings.

10.2.24 Attack Formation. Due to the inherent dangers of a high-threat environment, aircraft step-up is not a reliable means of providing safe separation. Lateral separation and good night vision techniques must be utilized to provide mutual support much the same as in a daylight environment. The wingman must be constantly aware of the leads position. He must position himself so as to be able to provide immediate supporting fire to as well as receive signals from the lead aircraft. With adequate terrain clearance and lateral separation, silhouetting the lead aircraft will aid in keeping it in sight, especially when operating lights out and wearing NVGs.

10.2.25 Night Troop Transport Escort. All helicopters may leave their exterior lights on unless receiving fire or in a place where they are likely to be receiving fire. The use of the anticollision light will depend on the integrity of the formation.

In a sophisticated threat environment, the formation used en route is determined by terrain, situation, and desired degree of control. Regardless of the specific formation, the helicopters will be staggered and the distance between helicopters will vary according to the terrain being crossed. Each aircrew in the flight is responsible for the accuracy of navigation and must be prepared to take the lead at any time and proceed to the destination. Light signals and code words should be used to assist in reducing radio communications and in the event of radio jamming by the enemy or lost communication.

When terrain flying, the greater the number of helicopters in a group, the more easily they can be detected. In addition, a large group requires more terrain relief to remain masked than does a small group. When large groups of helicopters are required to accomplish the mission, dispersion can be achieved by using numerous routes into an area with small groups of helicopters utilizing each route. However, it will often be necessary to use a single route in order to concentrate limited suppressive fires.

When moving, a small element of two or three helicopters should normally maintain its integrity so as to return an adequate volume of fire if attacked.

When it becomes necessary for attack runs to be made on a target, only one attack helicopter at a time should make the run. Lights may be used as necessary to ensure that all aircraft are clear prior to firing. When the wingman picks up to the lead aircraft he can commence his run. The tracers from the attacking gunship are normally reference enough for orbiting helicopters and they should not fire during periods when the positions of any other friendly helicopters are in doubt.

10.2.26 Night Reconnaissance. Tactics for night patrols are basically the same as for day patrols. The best times for these patrols are shortly after sunset and shortly before sunrise. Other times for patrol will be determined from intelligence reports on enemy movements. The main purpose of night patrol is to detect enemy movement. Report movement to nearest control agency and request instructions.

WARNING

Do not shoot unless you are sure the target area is clear of friendlies.

Exterior lighting for night patrols will vary with altitude and situation and at the discretion of the flight leader. When possible, prearranged flare points can be established with the agency providing the illumination and used to expedite the night reconnaissance mission. The attack helicopter will begin calling for the flares as he approaches the area.

10.2.27 Night Extractions. Night extractions require skill and pilot technique and normally are emergency situations.

1. Identification of the zone is normally made by illumination signals from the reconnaissance team using strobe lights, flashlights, or illumination grenades. It should be noted that strobe light resembles a muzzle flash at night, and crews should be briefed accordingly.

2. Flareships should be planned for all-night extractions to provide half light or twilight conditions when required.

3. The flaredrop can be controlled by the attack helicopter commander upon his arrival in the pickup area, or control may be passed to TAC(A) when deemed necessary by the attack helicopter commander.

10.3 ALL-WEATHER OPERATIONS

When weather precludes the use of normal operating procedures, the attack helicopter pilot must modify his tactics and employment to accomplish his mission. Because of reduced ceiling and visibility, the major areas of concern in inclement weather operations are maintaining flight safety and methods of navigation.

10.3.1 Radar. The attack helicopter pilot may utilize available radar coverage for flight separation and navigation. These services will be available in most operating areas. Radar may be used for vectors from an IFR area to a VFR area where the flight may continue with its mission. With close cooperation between the controlling agency and the attack helicopter unit, the helicopters may be vectored directly to a perch position where an attack run may be commenced for prebriefed targets.

10.3.2 Navigational Aids. Navigational aids should be used for flight direction and separation where required. With training and experience, safe flight separation can be maintained with the use of navigational aids only.

10.3.3 Formations. Visual contact should be maintained between all elements of the flight. The normal position used in reduced visibility conditions is the parade position.

CAUTION

Lost sight and inadvertent IFR procedures should be completely briefed with all elements of the flight.

10.4 NIGHT FLIGHT TECHNIQUES

Also refer to Chapter 13 and 18 of NWP 55-9-ASH, Vol. I.

10.4.1 Tactical Formations. Compared to day formation flight, the diminishment in night visual acuity, depth perception, and the inability to see relative motion make tactical formation flight at night more difficult to execute. Generally, flight integrity is harder to maintain, flight maneuverability is restricted, and there is an increased risk of midair collision. The problems of perception, flight integrity, and maneuverability compound to an unacceptable level for flights larger than three aircraft using tactical cruise information and fuselage and blade tip formation lights as the only sources of aircraft lighting. In other words, the number two and three wingman can maintain visual contact and can maneuver with the flight leader; whereas, the number four wingmen will probably lose sight of the leader during tactical maneuvering resulting in a loss of flight integrity and creating the potential for midair collision.

10.4.2 Tactical Approaches and Departures. The approach technique used at night should require a minimum of aircraft maneuvering, should provide sufficient altitude and straightaway during the final approach to permit a safe rate of descent, and should provide adequate visual cues to maintain spatial orientation. Straight-in initial approaches combined with either normal approach finals or precision approach finals are recommended for night operations.

The primary consideration for a night tactical departure is to obtain safe terrain and obstacle clearance altitude as quickly as possible. Straight climbout or spiral climbout departures are recommended for night operations.

Due consideration shall be given to the support capabilities and limitations of the attack helicopter escorts when night tactical approach and departure techniques are selected. To provide safe and effective support the flight coordinator must know the course of action, must be able to identify friendly positions and the approach/departure routes, and must understand the flight techniques to be employed.

10.4.3 Evasive Maneuvers. The basic concepts and procedures outlined in Chapter 12 for evasive maneuvers also apply to night operations. However, evasive maneuvers at night shall be carefully coordinated, controlled, and executed to prevent loss of flight integrity and to minimize the risk of aircraft collision. An evasive break conducted at night differs from a day evasive break in that it shall not be executed as an immediate action maximum performance turning maneuver. Rather, when compared to day procedures, it shall be initiated slowly and smoothly, it shall employ moderate angles of bank (30° or less) and normal lateral separation responsibilities shall remain in effect throughout the maneuver. Altitude changes shall be announced, moderate rates of climb and descent shall be used, and the flight shall not descend below the established altitude for safe terrain and obstacle clearance.

10.4.4 Aircraft Lighting. Night tactical operations should, to the maximum extent possible, make exclusive use of fuselage and blade tip formation lights. These lights are adequate for tactical formation flying and are shielded to prevent visual detection by ground-based enemy observers. Steady dim or bright aircraft navigational lights may be used momentarily, as necessary, to provide a reference for visual acquisition, aircraft separation, rendezvous, and/or escort support purposes.

Certain missions conducted in close proximity to the enemy (e.g., an urgent medevac, emergency resupply, or emergnecy reconnaissance patrol extraction) may require that all external lights be extinguished during the landing approach. The use of this procedure shall be planned and coordinated with the flight coordinator to preclude loss of, or hindrance to, escort support during the approach. The flight coordinator must either be able to see the approaching helicopter and friendly positions or have visual reference with an area where fire can be delivered safely. This procedure shall be used only for landing approaches conducted by a single helicopter.

Although either landing zone lighting or flare illumination shall be employed for each night tactical landing zone, it may be necessary to augment such illumination and lighting support with the helicopter's landing/searchlight. Because of the tactical advantage which the enemy may gain, such action must be carefully considered prior to use. However, when necessary, the light should not be used above 300-feet AGL because it is ineffective and should only be used intermittently and momentarily as required to clear obstacles and/or locate the landing zone. Intermittent, momentary use of the light presents a fleeting and difficult target for the enemy gunner. The pilot should be prepared to experience a sudden reduction in night vision capability outside the helicopter when the light is extinguished.

CAUTION

Under certain atmospheric conditions such as haze, smoke, fog, or high moisture content, the landing/searchlight may reduce visibility if used prematurely.

Whenever hovering or landing operations require an aircraft light source, either shielded or red-lens hover lights or steady bright or dim navigation lights should be used rather than the landing/searchlight. Such lights should be extinguished after touchdown when conducting single aircraft operations. When wearing NVGs, the landing/search light equipped with an infrared filter is effective and invisible to the unaided eye.

10.4.5 Adverse Meteorological Conditions at Night. At night, adverse weather conditions may be encountered unexpectedly. Ground visibility restrictions and clouds may form below the flight altitude. This condition can usually be identified by the gradual obscuration of ground reference points. Clouds at the flight level being flown are difficult to identify and may not be detected until cloud entry. Obscuration of the moon or stars indicate an overhead cloud cover. When an encounter with adverse weather at night is anticipated or imminent, a reversal in course should be executed while visual flight conditions still prevail to avoid inadvertent entry into instrument meteorological conditions with a flight of helicopters. The inadvertent IFR procedures established by the applicable NATOPS flight manual shall be briefed by the flight leader prior to flight and executed on his command when flight integrity can no loger be maintained by visual reference. Additionally, the minimum obstruction clearance altitude and the available air traffic control facilities and procedures shall be identified during the mission brief.

10.4.6 Night Vision Devices. There are two types of night vision aids being developed: amplification of ambient light (image enhancement) and infrared (IR).

10.4.6.1 Infrared Devices. (Data not available.)

10.4.6.2 Image Enhancement — Night Vision Goggles. Night vision goggles use light amplification to provide night vision capability. An auxiliary infrared light source provides illumination for closeup work when ambient light is inadequate. See Appendix F for description and use and Appendix D of NWP 55-9-ASH, Vol. I.

10.5 NIGHT TERRAIN FLIGHT PLANNING GUIDELINES

The criteria used for planning a mission involving terrain flight at night are basically the same as for day terrain flight missions. To successfully operate at terrain flight altitudes at night, aviators must be aware of the hazards and limitations and learn to cope with them.

10.5.1 General Considerations

10.5.1.1 Psychological and Physiological Stress. During day terrain flight, obstructions along the flightpath can be seen at great distances and the aircraft can be safely maneuvered to avoid them. At night, during periods of low light levels, it is more difficult to see obstructions that lie along the flightpath. Awareness of this limitation causes fear. As a result, fatigue develops, judgment is impaired, reaction time is slower, and flight proficiency is degraded. As the aviator becomes more experienced in night terrain flight, more confidence is developed in the ability to conduct night flight. Continuous flight training and rigid application of the factors for personal preparation are necessary to cope with limitations associated with psychological and physiological stresses.

10.5.1.2 Hemispherical Illumination. Because the phase angle of the moon changes daily, varying levels of light will be experienced each day of the moon's cycle. Also, changes in the moon's altitude each hour of the night will result in change in available ambient light. Detailed planning is required to determine when the optimum dates and times exist for conducting night terrain flight. The light level must be a consideration in determing the mode or terrain flight that should be flown for any particular mission.

10.5.1.3 Meteorology. Cloud coverage which normally would not restrict day terrain flight may prevent night terrain flight. At night, clouds obscure the illumination from the moon and other hemispherical bodies. The density of clouds and the amount of sky coverage will determine the available light that will be available on the ground. Restrictions to visibility-light drizzle, fog, smoke, and haze - also limit the available light. To conduct night terrain flight, sufficient light must be available to see objects and terrain features which lie along the flight route. When visual acuity is reduced to the point that terrain interpretation is ineffective, it is unsafe to continue the mission. Climbing to a higher altitude will not improve your visual acuity.

10.5.1.4 Navigation. Navigation at terrain flight altitudes is difficult because the distance that an object can be seen is significantly reduced. Although the helicopter is flown at a slower airspeed, the apparent ground speed appears to be faster when flying at terrain flight altitudes. Because of these limitations, accuracy of navigation is difficult and disorientation is likely. Positive identification of manmade or natural features is required to ensure accurate navigation. Detailed planning and teamwork are the key to ensure the success of the mission.

10.5.1.5 Radio Communication. Air-to-ground communication is significantly restricted, if not impossible. When operating at terrain flight altitudes, masking between the helicopter and the ground station occurs. As a result, radios; e.g., FM, UHF, which require line-of-sight propagation become unreliable. Variations in the sky waves occur causing erratic operations. By constructing a terrain profile, it can be determined at what locations along the route radio communications could best be achieved. By predetermining these points, prearranged signals can be transmitted as the aircraft passes these positions. Detailed planning must be effected to ensure that the mission can be accomplished without radio communications with the ground station. Visual communication signals which allow the mission commander to control the flight when radio silence is required must be established and become a part of the unit's SOP.

10.5.1.6 Night Vision. In combat, the enemy may use high-intensity lights to illuminate aircraft. Other sources of light on the battlefield are fires, flares, weapon flashes, and lightning. Every effort must be made to avoid direct viewing of these light sources. Normally, exposure to a light source does not affect crewmembers to the same degree. If two pilots are employed, the one who is affected the least should pilot the aircraft.

10.5.1.7 Manmade Obstructions. Detection of wires and other manmade obstructions is difficult at night. Reduced airspeed allows more time to detect wires and to take corrective action. Identification of wires may be accomplished by association with manmade features. When flying over wooded areas, long linear openings may represent wire locations. Wires may be detected by recognizing the poles to which the wires are attached. Normally, these poles can be found beside highways. If a dwelling is observed in an open area, wires can be anticiapted in the field near the building. Because trees are normally higher than wires, the possibility of striking a wire is less likely to occur when flight is conducted over a forested area. Transmission lines suspended on steel structures pose the highest wire obstacles. *Prior knowledge of the existence of a manmade obstruction is essential.* Information relating to these obstructions should be plotted on a hazard map and made available to the aircrews when planning a night terrain flight.

During night terrain flight, helicopters are particularly vulnerable to blade strikes when operating at low altitudes. Extreme care must be taken. The area where maneuvers are performed at night should be larger than that required during the day. Crewmembers should assist by advising the pilot of the helicopter's position in relation to obstacles.

10.5.1.8 Additional Obstructions. Birds are a hazard to night terrain flight. Upon encountering a flock of birds, maintain heading. Any abrupt change in heading may cause inadvertent contact with terrain obstacles, or it may induce vertigo because of the sudden change in attitude. Since birds tend to disperse laterally with little ascent, a straight ahead climb will normally clear the helicopter of the birds.

10.5.1.9 Terrain. Ease of navigation will depend on the vegetation in the area. When traveling over a desert environment, it may be difficult to judge distances and altitude due to lack of depth perception and terrain features. Farmland (cultivated fields) aids in navigation. The seasons have an impact on navigation. If it is spring or fall, fields will be very distinguishable. If it is winter, fields may not be easily identifiable due to snow coverage. Navigating in a jungle environment is extremely difficult due to the lack of contrast and the lack of distinguishable features.

10.5.1.10 Populated Areas. Artificial light sources are helpful in navigation. The degree of artificial light depends on the population in the area. Desolate areas usually have few light sources available. Small villages or towns provide a light source which aids in navigation. Normally, cities have added features such as light towers. A large metropolitan area provides many light sources to aid in navigation. An important point to consider is the actual amount of light sources which will be available.

10.5.1.11 En Route Data. The altitude and airspeed which will be used depends on the threat, terrain, moon illumination, contrast, and weather. These factors must be evaluated to determine whether to fly at altitude (above 200 feet), low level, contour, and/or NOE. Airspeed should be slower when the visibility decreases to prevent inadvertent IMC conditions.

10.6 NIGHT VISION GOGGLE MISSION PLANNING

10.6.1 General. The successful completion of missions involving the use of NVG is directly related to the amount and quality of premission planning performed. Although special operations and related training always require extremely detailed and extensive planning, many of the same techniques and procedures apply to all NVG-related missions.

The most difficult task performed with the NVG is unaided navigation and therefore demands the most attention in the premission planning phase of the operation. As navigational aids are generally avoided and onboard navigational equipment is subject to failure, it is imperative that the aviator be proficient in and rely primarily on pilotage and dead reckoning for accurate navigation.

This information discusses only the basic techniques and procedures required for NVG navigation. It is not all inclusive nor does it represent the only solution, but all of the techniques/procedures have proven highly successful.

10.6.2 Route Planning. The navigation route to and from the objective area must be tactically sound but not so difficult as to deter successful navigation. Each mission will differ and will involve numerous variables. Below are general rules of NVG route selection:

1. Avoid brightly lit areas, roads, and population centers.

2. Avoid planning the route near navigational aids or airports due to the hazards associated with other aviation operations and to avoid detection by radar oriented on these facilities.

3. Plan to negotiate large N-S valleys on the lighted side, in reference to the moon's position, to avoid the shadows cast by the

moon and to permit silhouetting of terrain features for navigation.

4. Plan to negotiate narrow valleys and passes E-W/W-E so that the terrain will be lit and shadows avoided.

5. Never plan a route that heads directly into a low-angle rising or descending moon. Alter the course as necessary to fly a zig-zag course when left with no other choice.

6. Avoid planning route segments requiring heading changes of more than 60°. This is especially critical when in formation.

7. Always select intermediate reference points, in addition to checkpoints, along each leg of the route for course confirmation and timing. The lower the ambient light, the more reference points should be used.

8. If possible, plan to cross major roads and railroads at large angles, e.g., 90°, in order to reduce exposure time.

9. If it is impossible to avoid flight near population centers or flight near major roads, plan to maintain at least cruise airspeeds in order to reduce exposure time.

10. When computing times, distances, and headings for the route, always compute the same information from barriers and prominent map features; this will greatly aid in reestablishing the flight on course if a CP is missed or the flight becomes disoriented. Log this information on the navigation map.

11. Plan the times at which you should cross prominent intersecting features, i.e., roads, rivers, RRs, to facilitate timing and navigation.

12. Always anticipate wires associated with all roads, towers, and buildings in open fields.

13. Always plan alternate routes and bypasses in the event the primary route is blocked due to weather, enemy compromise, and so forth.

10.6.2.1 Control/Checkpoint Planning. After a general route has been determined to the objective, select CPs and checkpoints to control movement along the route. Study the CPs carefully using all available maps and photographs. Below are general rules for NVG checkpoint selection:

1. CPs should be unique natural or manmade features which are detectable at a distance, not just visible only when flying directly overhead.

2. CPs should contrast with the surrounding terrain. For example, paved roads are poor features to use in terrain with heavy vegetation, but they provide excellent contrast in a desert environment. Small bodies of water provide very little contrast in terrain with vegetation but contrast well in the desert.

3. Avoid selecting CPs near towns as the town invariably grows and may alter or make detection of the checkpoint difficult.

4. CPs should not be in the vicinity of bright lights.

5. CPs should always be confirmed by an adjacent prominent feature along the route to alert the pilot that the CP is approaching.

6. Always consider and determine the moon angle and percent. The checkpoint must never fall within the shadow cast by a nearby terrain feature.

7. Where possible, checkpoints should be at least 5 nm apart and no more than 20 nm apart.

8. Always select prominent barriers near CPs, especially where a turn is planned. It is

often better to discard a good checkpoint with no barrier in favor of a more difficult checkpoint with an excellent barrier.

9. The first and last checkpoints of the route are the most important. An easily identifiable feature must be used even if the flight route must be altered slightly. The first and last checkpoints should be approximately 5 nm from the departure point and objective, respectively, to ensure absolute positive location and timing. Never have a long final leg of more than 5 to 8 nm into the objective to preclude compromise of the mission and to ensure timing.

10. Make note of the MSL altitude of each checkpoint during planning, in varying terrain, and to aid in CP confirmation.

11. All intermediate landing areas or contingency LZs must have a CP associated with the final approach leg.

10.6.3 Navigation Techniques. Navigation with night vision goggles is a difficult and challenging evolution. Certain techniques will aid in making navigation with the goggles an easier operation.

There are basically three methods of using the goggles for navigation. One method is to have the navigator strap the goggles to his helmet and focus onto the map and then out to the terrain, focus back to the map, and so on. In utilizing this first method, the recommended technique is to focus the lenses to infinity and adjust one lens to read the map when desired. After reading the map, the lens is readjusted to infinity. Closing the eye behind the lens not being used will help maintain a clear picture. The second technique is to have the navigator hang the goggles around his neck using a small penlight to illuminate the map. The navigator then puts the goggles to his face (both lenses focused outside), finds the feature he has just seen on the map, removes the goggles, looks at the map with his penlight, etc. The third method involves total memorization of the routes of flight so as not to need a map to navigate with, except in cases of disorientation. Use of AN/AVS-6 and the AN/PVS-5 with modified face plate, plus the blue/green lighting kit will allow the navigator to more easily read the map due to the look-around design.

The AN/PVS-5's integral IR source is a good device for illuminating the map you are navigating with. Up to a point, the more light you have to illuminate the map with, the easier the map will be to read. A blue- or green-lensed flashlight may help in augmenting the IR sources. Whatever illumination technique is used, remember that enemy night vision devices can acquire your IR source or flashlight. Light discipline must be stressed and enforced in all night missions.

Depending on the length of the mission, exchanging flying and navigating duties in the middle of a mission is not a good idea. If possible, the pilot who starts out navigating should continue to navigate until the mission is complete. Disorientation could be a problem if you attempt to split the flying and navigating duties especially on a difficult route.

The method of navigating with the NVGs will depend on the mission, the amount of illumination, and the difficulty of the route, as well as the level of training and experience of the aircrew. In any case, the mission will require complete briefing and assignment of the most insignificant of crew responsibilities. Ensure that the crew chief or other enlisted or officer crewmembers are thoroughly briefed. Nonpilot crewmembers can be a big help in locating terrain features that may be difficult for the pilots to see.

10.6.4 NVG Map Preparation. The following techniques and considerations are used to prepare the NVG map.

1. Use a bright black liquid ink pen only.

2. Place the route and CPs on the map first, and then begin preparation.

3. To permit orientation of the map quickly in flight, place a large N symbol on each fold of the map in order of use.

4. Prepare the map, as a minimum, 8 to 10 nm on either side of the route in case the flight should depart the course line for any reasons.

5. Lighted towers, beacons, cities, etc., should be marked out to a distance of at least 30 nm.

6. Do not overprepare the map. Outline those features which you will expect to see (dirt roads, trails, and creeks, in most areas, will not likely be seen and only clutter the map; the opposite case exists in desert terrain).

7. Transfer key features from the VFR sectional and tactical map to the JOG.

8. Do not overly exaggerate any map feature.

9. All notes and writing should be oriented in the direction of flight for that particular leg.

10. Use one map per mission. Never attempt to use the same map for a different mission in the same area.

11. Mark contour lines at 500-foot altitude intervals. Do not mark contour lines in relatively flat terrain as it leads to confusion.

12. Standardize and use the following NVG map symbols or similar:

(1) Course line

(2) Major paved roads

(3) Secondary roads

(4) Power line

(5) Major rivers

(6) Bodies of water

(7) Small rivers/streams

(8) Railroad tracks

(9) Small town

(10) Phase lines

(11) Fields or LZs

(12) Airports w/beacons

(13) Towers

(14) Bridges

(15) Mountains/hills

(16) Dry washes

(17) Targets

(18) Cities

10.6.5 NVG En Route Cards. Route cards (Figure 10-1) are constructed with the same basic criteria as the navigation (NVG) cards and display all essential information for each particular leg of the road:

1. Route cards are constructed one for each leg of the flight and one for the ojbective area, FARP, holding area, and departure point, as appropriate.

2. Route cards must be made to scale and as accurately as possible.

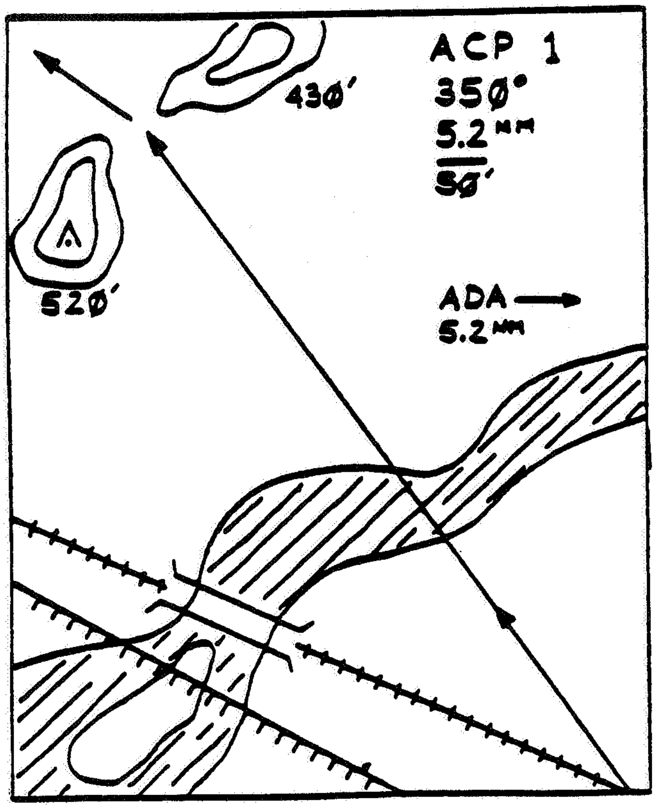


Figure 10-1. NVG En Route Card

3. These cards are normally referred to, in lieu of the map, during single-pilot operations.

4. Completed route cards are placed in plastic envelopes of corresponding size, secured with metal rings and hung in the vicinity of the instrument panel.

10.6.6 NVG Navigation Card. The NVG navigation card (Figures 10-2 and 10-3) are constructed from 5" x 8" white or light-colored cards. All essential information for the navigation portion of the mission is included on the card. The card has intentionally been kept simple in format and construction to allow for NVG compatibility:

1. All lines and writing on the cards are made with a bright black ink which will contrast well with the light-colored cards.

2. All letters and number are made at least 1/4" in size.

3. The HDG degree and NM abbreviation are used to prevent confusion with the time column during low-illumination conditions.

4. The remarks column is used for pertinent information and to describe the appropriate checkpoint.

5. No more than eight legs should be used per card.

6. Completed cards are placed in plastic envelopes of corresponding size, secured with metal rings, and placed on a kneeboard or hung from the aircraft instrument panel.

7. The upper left portion of the HDG column indicates magnetic heading while the lower right portion indicates the course (track across ground).

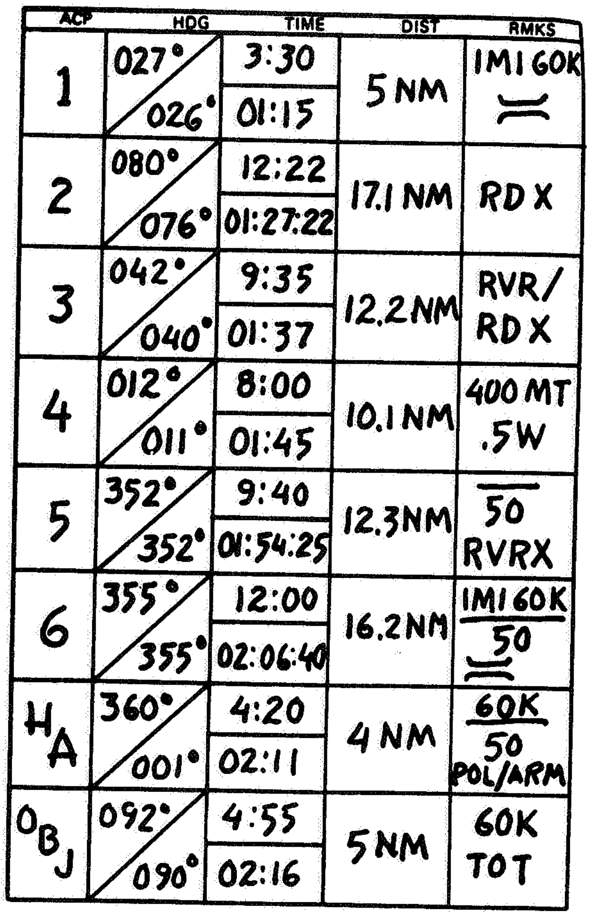
8. The upper half of the TIME column is used for ETE, and the lower half is used for ETA.

10.7 NIGHT TOW FIRING

Combat necessity may require firing TOW missiles during periods of darkness. Certain procedures must be accomplished in order to successfully complete this mission.

10.7.1 Preflight

1. Disconnect the connector plug on the TSU aft relay assembly. This removes power to the TSU GUNS, ATTK, and RDY indicators so as to avoid NVG white out.



ACP	HDG	TIME	DIST	RMKS
1	027° 026°	3:30 01:15	5 NM	IMI 60K ≍
2	080° 076°	12:22 01:27:22	17.1 NM	RD X
3	042° 040°	9:35 01:37	12.2 NM	RVR/ RD X
4	012° 011°	8:00 01:45	10.1 NM	400 MT .5W
5	352° 352°	9:40 01:54:25	12.3 NM	50 RVRX
6	355° 355°	12:00 02:06:40	16.2 NM	IMI 60K 50 ≍
HA	360° 001°	4:20 02:11	4 NM	60K 50 POL/ARM
OBJ	092° 090°	4:55 02:16	5 NM	60K TOT

Figure 10-2. NVG Navigation Card (Completed)

Note

With power removed from the TSU GUNS, ATTK, and RDY indicators, it becomes necessary for the pilot to inform the gunner when the aircraft is in prelaunch constraints.

1. Copilot must tape over all cockpit lights that will adversely affect use of the NVGs.

3. Focus the TSU during daylight.

4. Focus the NVGs at infinity during NVG preflight.

5. Determine which eye will be used so the eyepiece may be rotated accordingly. The use of one eye only improves target resolution.

6. Double check NVG focus prior to launch.

Note

On the battlefield, the gunner will have to accept a happy medium of focus between the target and the sight reticle as the NVGs will not allow primary focus on either.

10.7.2 Prelaunch

1. Determine target center of mass and direction of movement. This may be accomplished by deducting a distance/angle relationship between the following items:

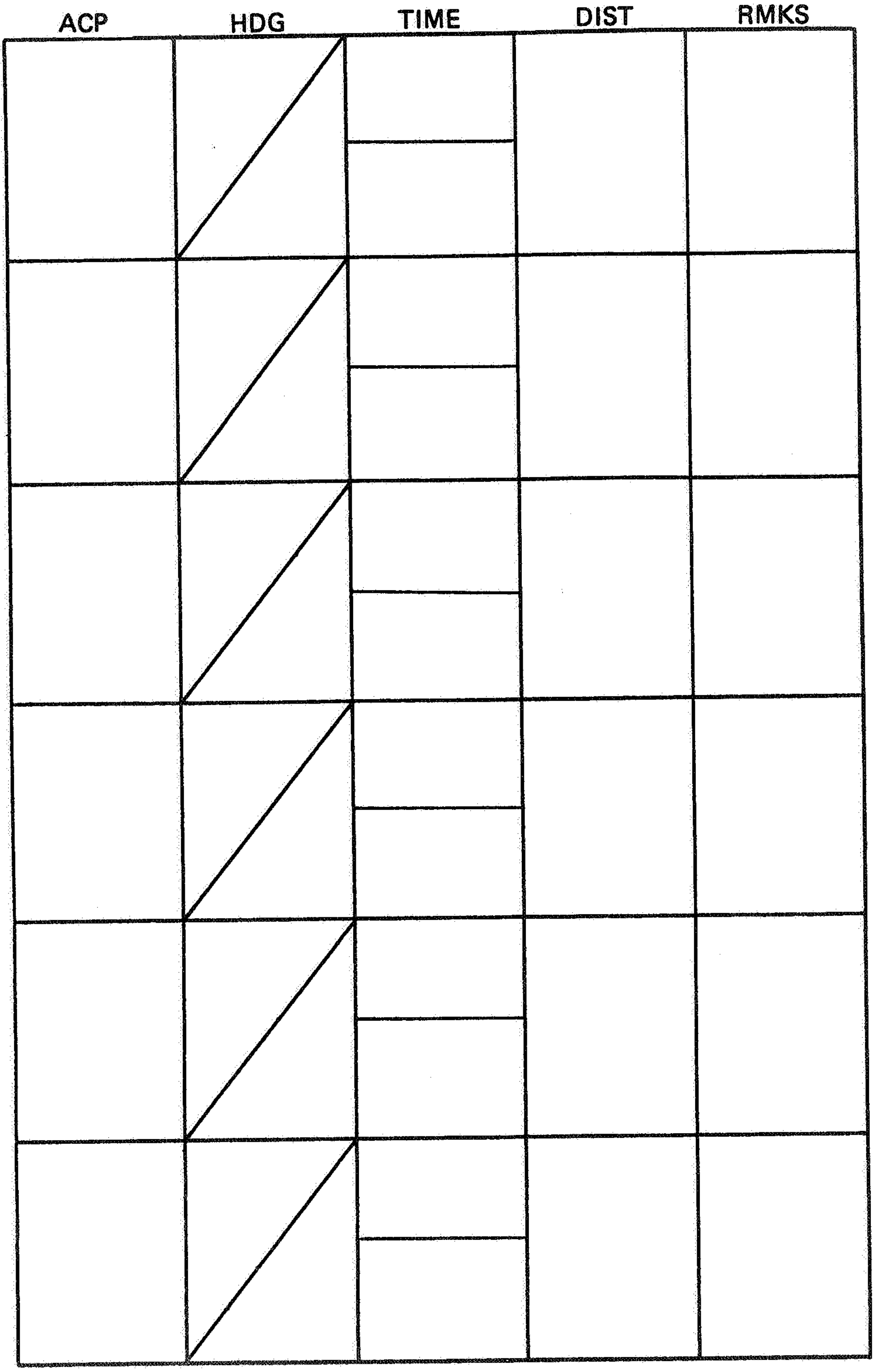
   (a) Black-out lights (cat-eyes).

   (b) Periscope light (reflected light from the vehicles instrument panel).

   (c) Engine IR signature.

2. Distance is determined by use of the WERM rule.

10.7.3 Firing Techniques. When firing the TOW missile at night with the NVG's, the intensity of the light produced by the missile motor and IR emitter causes the gunner to lose sight of the target until the missile is approximately 1000 meters down range. The following techniques may be used to compensate for this problem.



ACP	HDG	TIME	DIST	RMKS

Figure 10-3. NVG Navigation Card (Sample)

1. The first technique requires the gunner to comply with normal prelaunch procedures. Aftr the missile is fired, prelaunch tracking is maintained until the target reappears.

Limitations:

(a) Correction tracking to bring the sight reticle on the target may exceed the turn capabilities of the missile.

(b) The pilot must maintain the prelaunch heading until the gunner has reacquired the target (approximately 4 to 5 seconds).

(c) Corrections must be smooth, deliberate, and immediate.

2. The second technique requires the gunner to comply with normal prelaunch procedures. After the missile has been fired, he smoothly applies a tracking error that causes the missile to fly either left or right of the line of sight to the target. After the missile is beyond a range that the light intensity of the missile motor does not block out the target, the gunner slowly corrects to bring the center of the sight reticle back on the target.

Limitations:

(a) Intentional tracking error induced may be excessive to correct back to the target.

3. The third technique is most preferable. The gunner intentionally fires the missile outside the target line of sight unitl it is beyond a range of approximately 1000 meters, thus allowing constant sight of the target throughout the flight of the missile. The gunner aligns the TSU on a point which is offset from the target. After the missile is fired, the gunner slowly applies correction to align the center of the sight reticle on the target (Figure 10-4). When employing this firing technique, the sight reticle should be offset to the side from which the missile is fired so as to move the TSU away from the missile IR emitter immediately. The distance the center of the sight reticle is offset from the target should not exceed the limits of the TSU sight reticle.

10.8 AERIAL FLARE EMPLOYMENT

Night combat operations are a must in order for our forces to survive on the modern battlefield. The enemy can be expected to rely heavily upon employment of armor attacks launched during the hours of darkness and continuing into daylight. As members of the combined arms team, attack helicopter units can contribute significantly in countering this armor threat. Using the flare rockets, attack helicopters illuminate their own targets or targets for other forces that may be beyond the range of other fire support means.

10.8.1 The Threat. To effectively employ aircraft in a high-threat environment, it is necessary to first understand the threat as described in Chapter 16. Aircrews must know the enemys situation and capabilities and must be able to evaluate the enemy's probable use of air defense weapons, artillery, high-performance aircraft, and helicopters. With this information, aircrews must evaluate the tactics presented in Chapter 14 to determine actions required to increase survivability.

The primary consideration of all aircrews is to avoid both electronic and visual detection. Although an aircrew cannot totally avoid detection, detection can be minimized by flying at terrain flight altitudes. Each principle of employment must be evaluated for the specific situation. By following the principles, the aircrew can attain optimum effectiveness, minimize vulnerability, and maximize survivability. (Figure 10-5.)

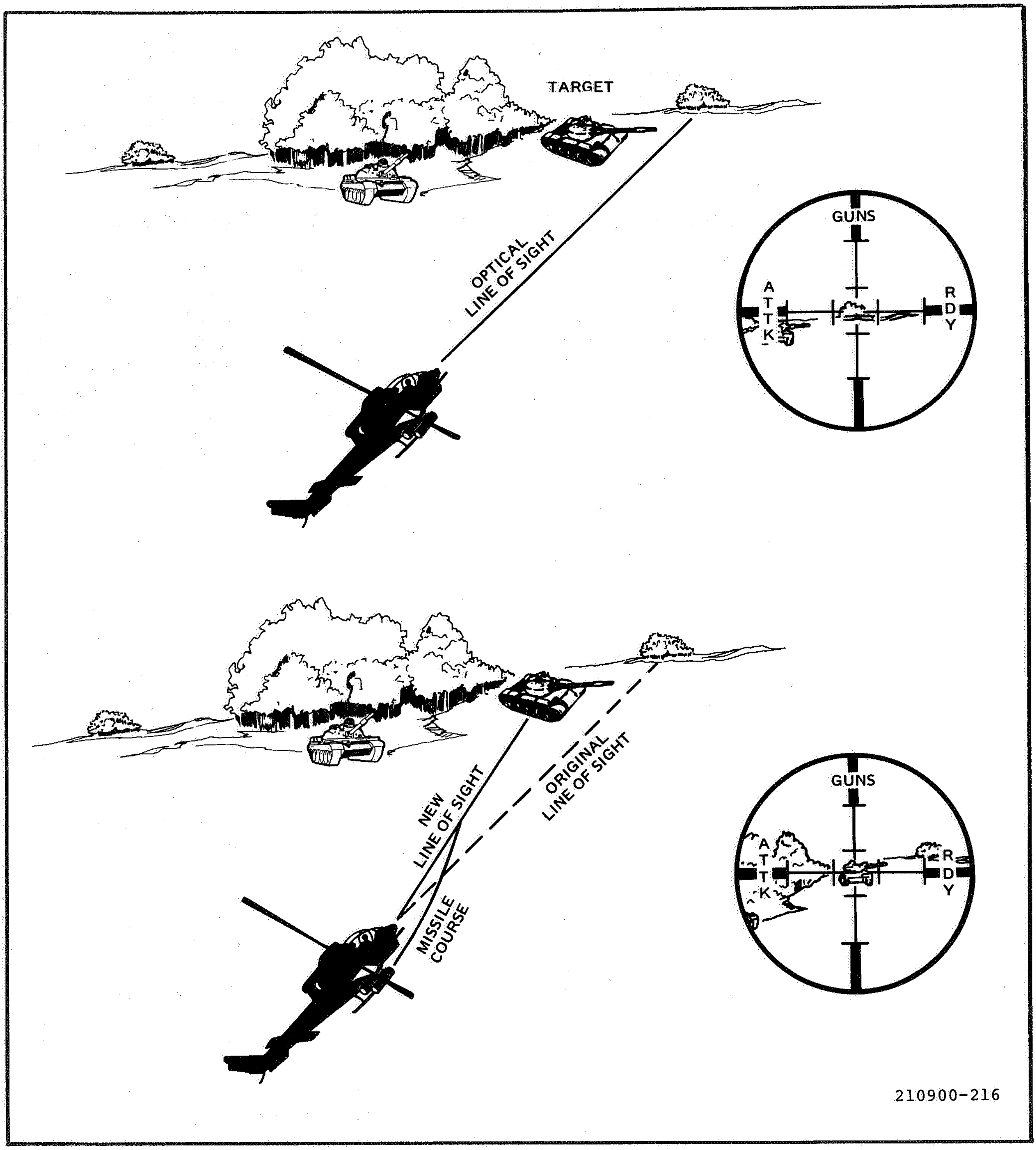
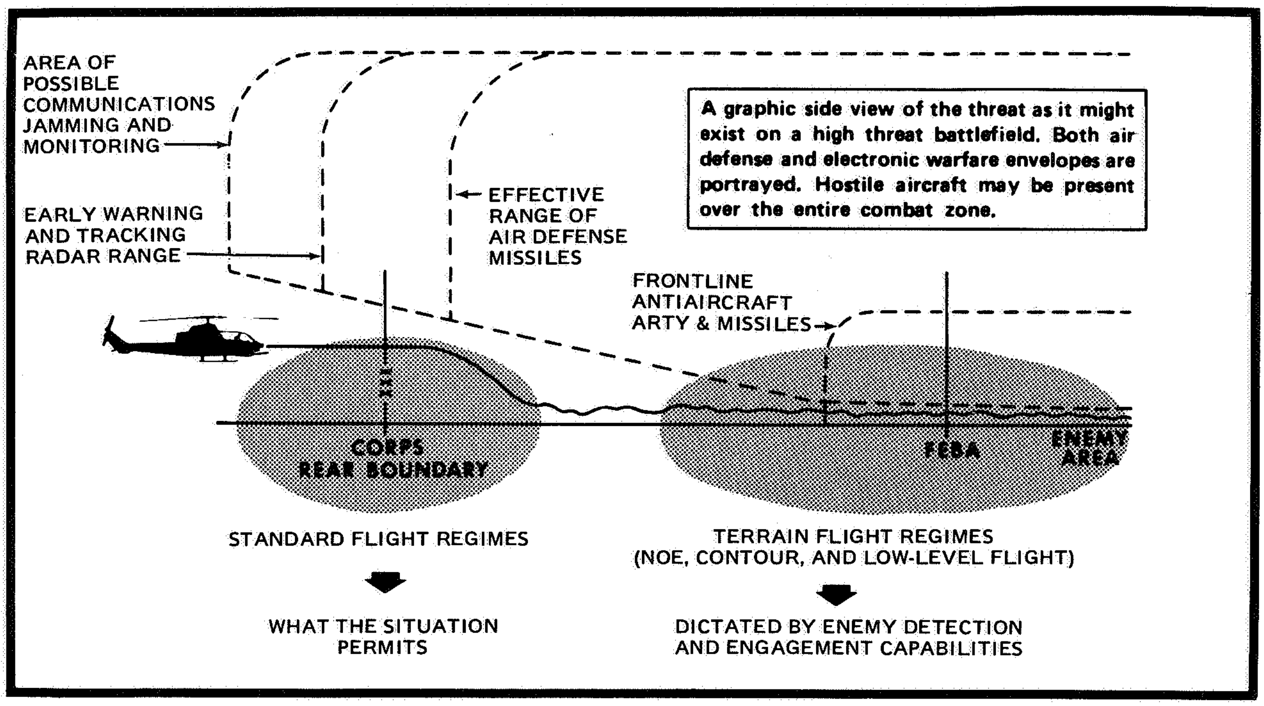


Figure 10-4. Firing Techniques


AREA OF POSSIBLE COMMUNICATIONS JAMMING AND MONITORING
EARLY WARNING AND TRACKING RADAR RANGE
EFFECTIVE RANGE OF AIR DEFENSE MISSILES
A graphic side view of the threat as it might exist on a high threat battlefield. Both air defense and electronic warfare envelopes are portrayed. Hostile aircraft may be present over the entire combat zone.
FRONTLINE ANTIAIRCRAFT ARTY & MISSILES
CORPS REAR BOUNDARY
FEBA
ENEMY AREA
STANDARD FLIGHT REGIMES
WHAT THE SITUATION PERMITS
TERRAIN FLIGHT REGIMES (NOE, CONTOUR, AND LOW-LEVEL FLIGHT)
DICTATED BY ENEMY DETECTION AND ENGAGEMENT CAPABILITIES

210900-217

Figure 10-5. Flight Regimes on a High Threat Battlefield

10.8.2 Target Identification. In order for an attack helicopter aircrew to engage targets at night, it must be capable of seeing them. To aid in identifying targets at night, aircrews use night vision devices that amplify ambient light (night vision goggles) and artificial illumination.

10.8.3 Artificial Illumination on the Battlefield. The primary means of artificial illumination on the battlefield has been by flares fired by field artillery and mortars. In contingency operations, targets requiring illumination may be beyond the range of supporting field artillery (A, Figure 10-6). The use of aircraft-dropped flares (B) subjects the flare-dispensing helicopter to the high risk of being destroyed by enemy air defense weapons. To overcome these limitations, the M257 illumination warhead has been developed for the 2.75-inch folding fin aerial rocket (FFAR) system. This new warhead gives the attack helicopter aircrew the capability to illuminate the target (C) from a safe distance and from a low altitude (D), thus reducing exposure to enemy detection.

10.8.4 M257 Illumination Warhead. The M257 illumination warhead, coupled with the 2.75-inch FFAR, gives the attack helicopter aircrew the capability to illuminate targets from standoff ranges equal to the maximum range of the TOW missile system.

10.8.5 Capabilities and Limitations. Under clear atmospheric conditions, one flare produces a constant illumination of 1,000,000 candle-

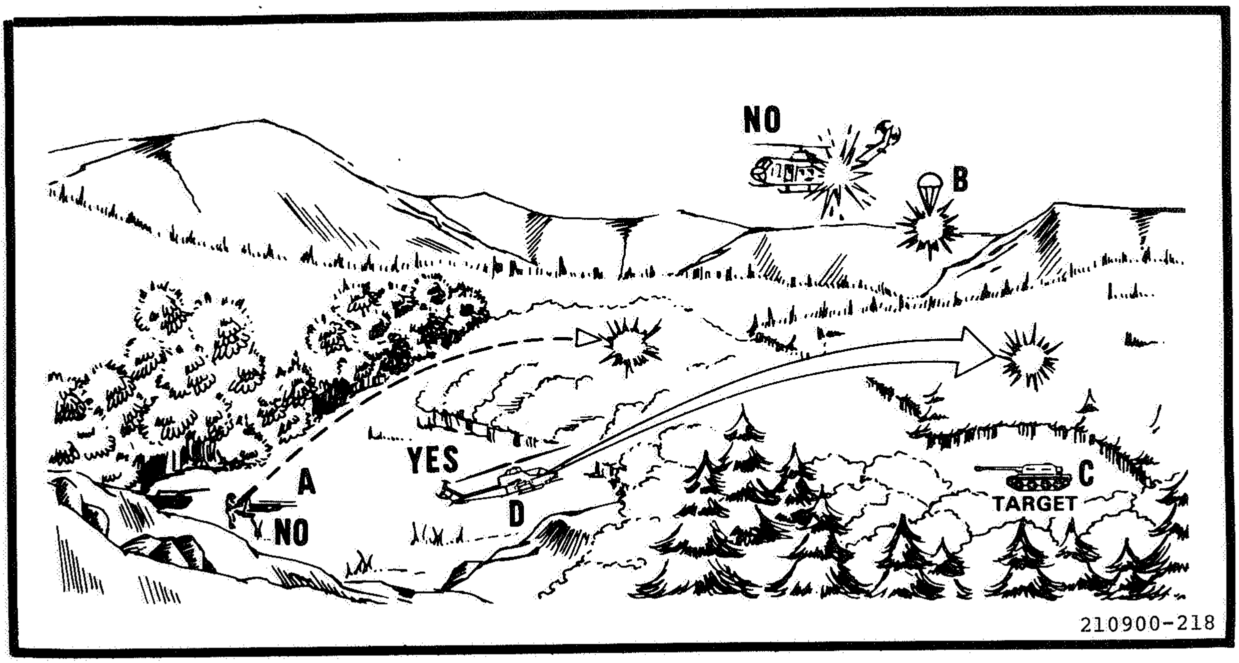


Figure 10-6. Artificial Illumination

power for approximately 2 minutes. Where visibility restrictions exist, the illumination intensity received on the ground will be reduced. Cloud cover above the flare will increase the intensity of illumination received on the ground. From an altitude of 1,000-feet AGL, one flare illuminates an area 460 meters in diameter with an illumination intensity of 0.5 foot-candles (25 times the ambient level of a full moon) at the outer edge. The light intensity decreases as the distance from the center increases. At a point 425 meters from the center, the light level decreases to the 0.2 foot-candle level. The illumination finally reaches its minimum usable level of 0.05 foot-candles at a distance of 760 meters from the center. (Figure 10-7.)

Optimum Flare Ignition Altitude	1800 Feet
Standoff Range	3000 Meters
Light Output	1,000,000 Candlepower
Light Duration	120 Seconds
Average Rate of Descent	13.0 Feet per Second

Figure 10-7. M257 Illumination Warhead Performance

Two flare rockets close to one another will produce two million candlepower of illumination or twice the intensity of one flare. Although two flare rockets double the intensity of illumination, they do not double the radius of illumination. For example, using one flare, 0.2-foot candle level of illumination is reached at 425 meters from the center. With two flares,

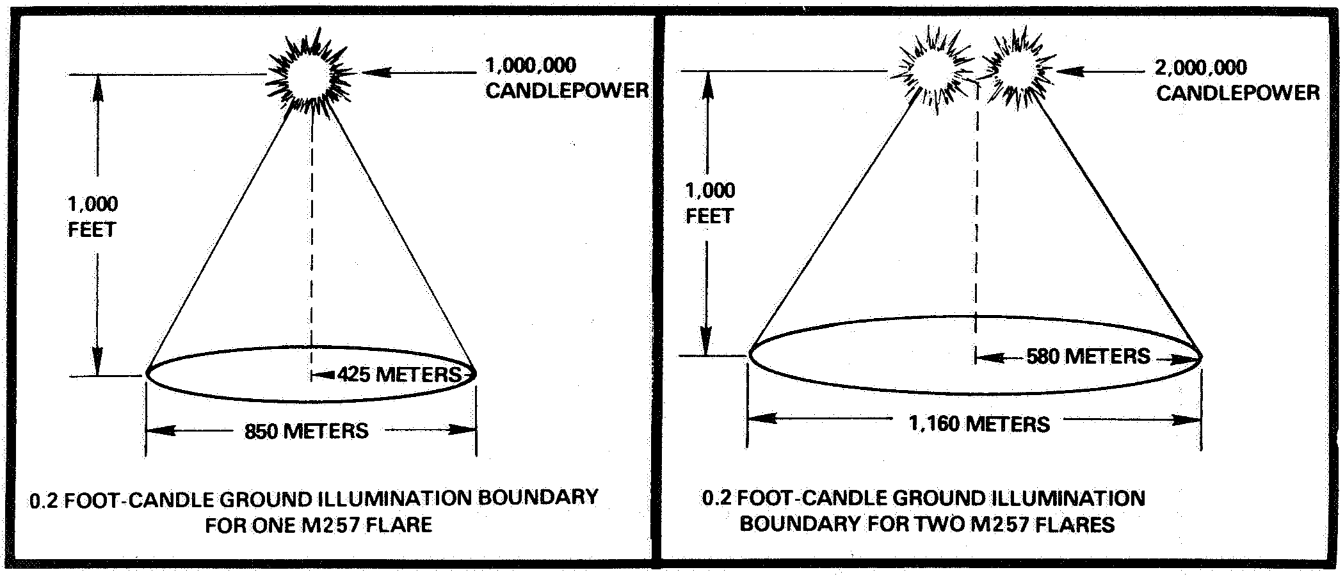

1,000,000 CANDLEPOWER
1,000 FEET
425 METERS
850 METERS
0.2 FOOT-CANDLE GROUND ILLUMINATION BOUNDARY FOR ONE M257 FLARE
2,000,000 CANDLEPOWER
1,000 FEET
580 METERS
1,160 METERS
0.2 FOOT-CANDLE GROUND ILLUMINATION BOUNDARY FOR TWO M257 FLARES
210900-219

Figure 10-8. Ground Illumination Boundary

this point is extended an additional 155 meters or 580 meters from the center. The use of two flares also increases the reliability of flare ignition over the target during an engagement. (Figure 10-8)

Targets that cannot be illuminated by one flare or two fired in close proximity will require multiple ignition points to cover the target. These ignition points must be equally spaced over the target area so as to allow a 25-percent overlap of the 0.2-candlepower candlepower illumination pattern. As a rule of thumb, the spacing between ignition points should be 700 meters when illuminating linear targets with one flare at each ignition point. When two flares are used at each ignition point, the spacing should be 1000 meters. Using the rule of thumb for single flare ignition, a target can be illuminated 1500 meters in length with a minimum intensity of 0.2 candlepower by spacing two flares 700 meters apart. If two flares are used at each ignition point, a target 2200 meters in length can be illuminated by spacing the ignition point 1000 meters apart. (Figure 10-9.)

To identify a tank silhouette at 2000 meters, a light intensity of at least 0.2-foot candles is required (0.2 foot-candles is equal to 10 times the ambient light level of a full moon). Prominent terrain features can be identified at 2000 meters, with a light level of 0.05-foot candles (2-1/2 times the ambient light level of a full moon). (Figure 10-10.)

WARNING

The spent rocket motor will impact the ground between 700 and 1000 meters beyond the target and along the trajectory of the rocket. During training, precaution should be taken to ensure that rocket flares are not fired over or toward friendly forces.

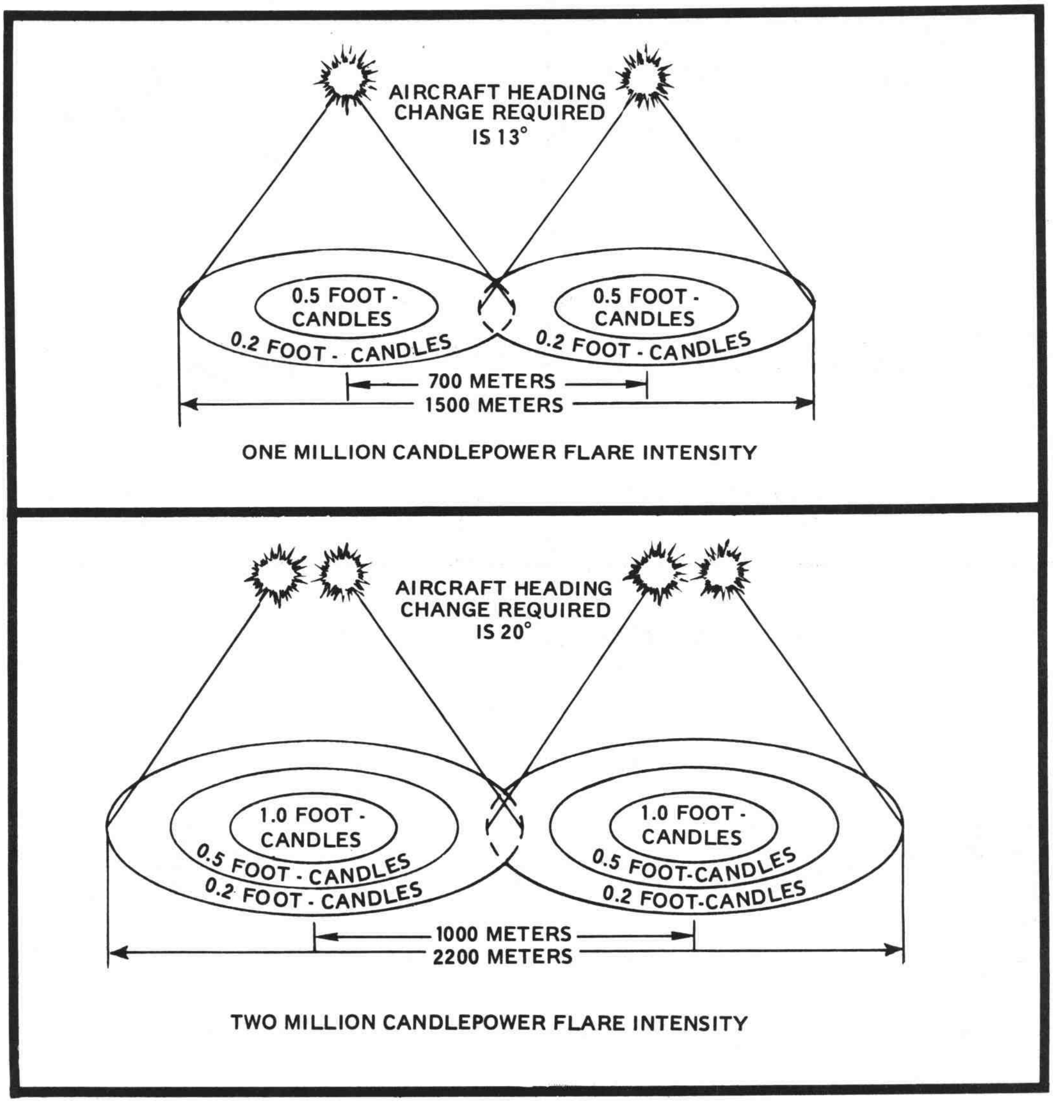


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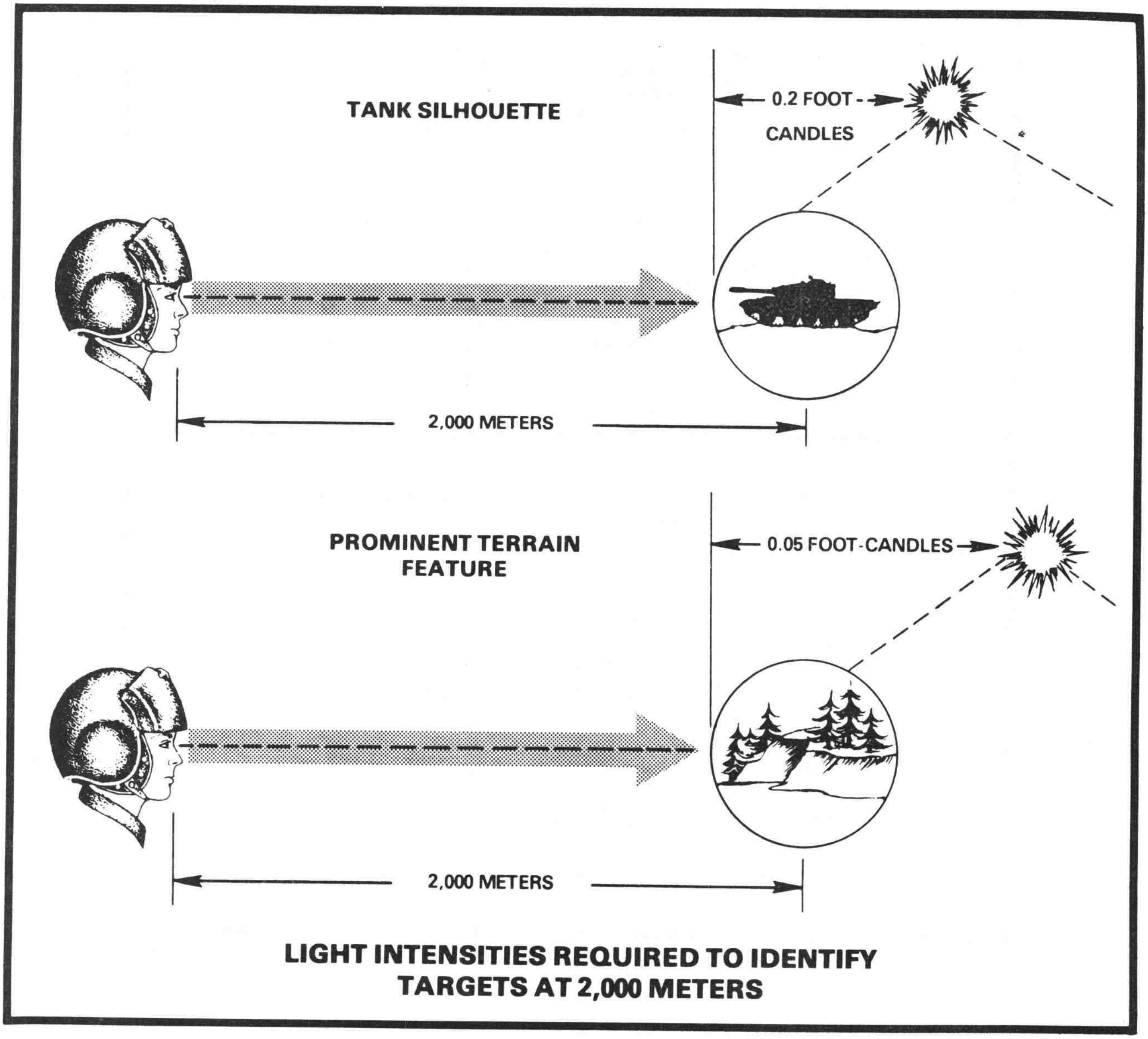
Figure 10-9. Overlapping Flare Illumination


TANK SILHOUETTE
0.2 FOOT-CANDLES
2,000 METERS
PROMINENT TERRAIN FEATURE
0.05 FOOT-CANDLES
2,000 METERS
LIGHT INTENSITIES REQUIRED TO IDENTIFY TARGETS AT 2,000 METERS

210900-221

Figure 10-10. Light Intensities Required to Identify Targets at 2,000 Meters

CAUTION

- The intensity of the flare rocket after ignition may cause the aircrew members firing these rockets to lose their night vision capability when performing the mission with the unaided eye. To avoid the loss of night vision, one crewmember should turn his head away from the illuminated area or close one eye when viewing the flare.

- Crewmembers wearing night vision devices should avoid visual line of sight with the rocket. Targets observed beneath the flare and off to the sides are not degraded by the light source when viewed throught the goggles.

10.8.6 Employment of Flare Rockets. In combat, aircrews must be capable of positioning the flare rocket over the target area on the first round or lose the tactical advantage gained by surprise. To achieve this degree of proficiency, the aircrew must acquire a knowledge of how to determine the proper firing direction and the proper delivery technique.

10.8.6.1 Delivery Techniques. The attack helicopter aircrew can illuminate targets using either hovering or running fire delivery techniques. Hover fire is the primary delivery technique because it minimizes exposure of the helicopter to enemy threat weapons and because it is less hazardous than using the running fire delivery technique at terrain flight altitudes at night. When using either of the delivery techniques, the flare rockets should be fired from a point 3000 meters from the target at the proper pitch attitude so as to ignite at 1,800 feet above ground level (AGL). This ignition altitude will allow the flare to produce the maximum illumination as it descends.

CAUTION

A flare rocket that ignites below an altitude of 1,800-feet AGL may contact the ground before burnout occurs and cause ground fires.

10.8.6.2 Hover Fire. Hover fire allows the aircrew to continuously illuminate a target requiring multiple points without exposing the helicopter to enemy observation and with a greater degree of accuracy. Additionally, this delivery technique requires less maneuvering than running fire. The hover fire delivery technique has a disadvantage in that rearward flight occurs when pitching the nose up to the firing attitude. Because rearward flight occurs, greater clearance should be available below and behind the helicopter.

When firing the flare rocket, greatest accuracy is achieved by firing from preselected firing points since this procedure permits accurate range and direction determination to the target area. Firing points should be located near a terrain feature that provides a good ground reference. When required to provide immediate illumination of a target where preselected firing points have not been selected, the aircrew must estimate the range to the target and position the helicopter so as to achieve the desired effect on the target. This procedure is less accurate for first-round effect and should be used only when immediate reaction illumination is required.

To achieve the desired flare ignition height, it is necessary to elevate the launcher a total of 23° above the horizontal reference. This is accomplished by using a launcher quadrant elevation of 71 mils (4°), and a 19° nose-high pitch attitude (Figure 10-11, Sheet 1). To obtain the proper pitch attitude, you must first determine the horizontal reference for the helicopter. This is accomplished by positioning the helicopter on level ground and adjusting the horizon bar on the attitude indicator so that level flight is indicated. When the helicopter

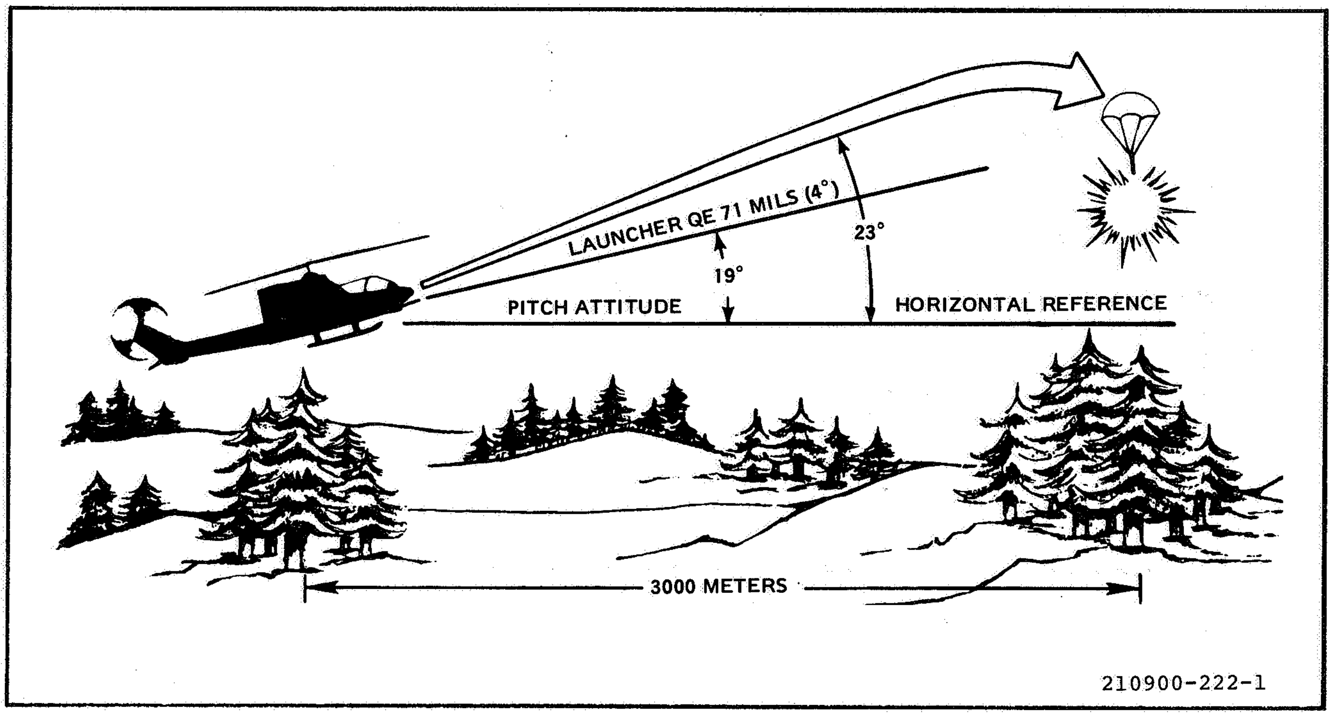
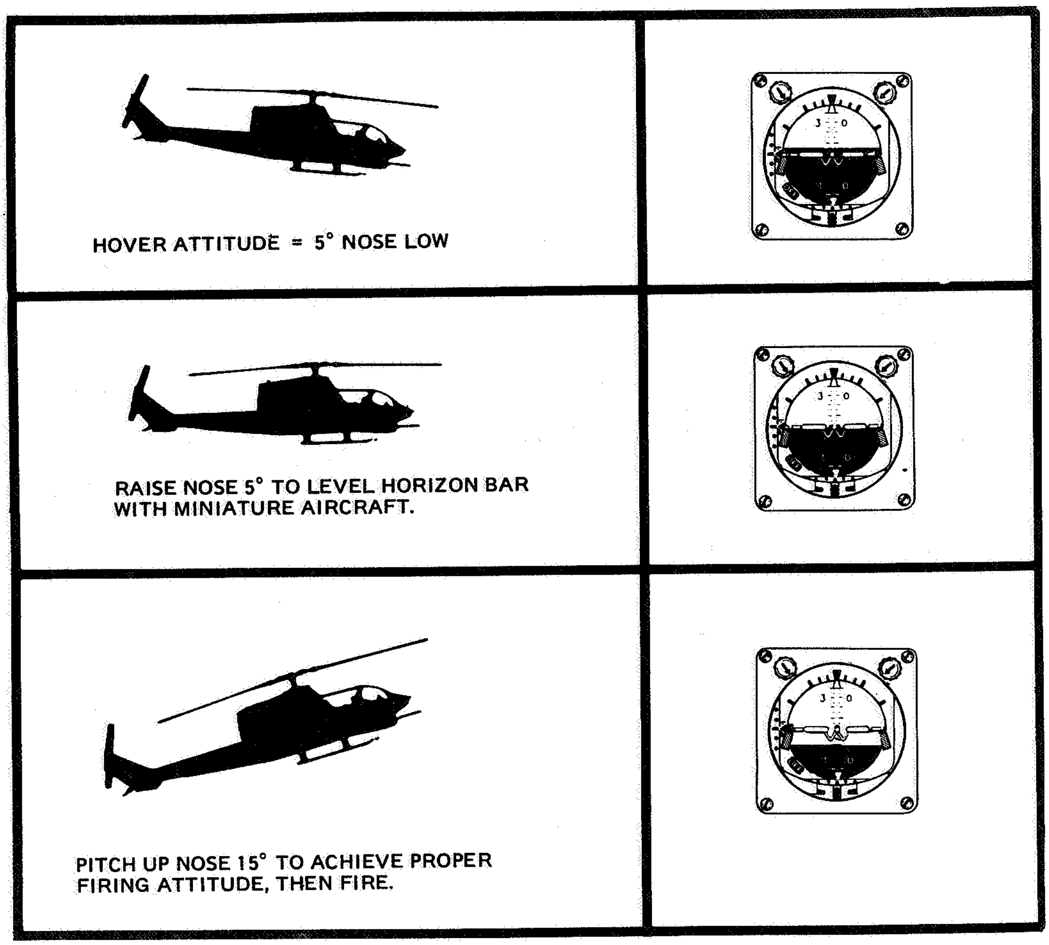


Figure 10-11. Attitude Adjustment for Desired Flare Ignition Height (Sheet 1 of 2)

ascends to a hover, the horizon bar will be displaced above the miniature aircraft indicating a nose-low attitude (Figure 10-11, Sheet 2). The position of the horizon bar above the miniature aircraft is the horizontal reference and will vary from one helicopter to another, depending on the current configuration and the weight of the aircrew. You may elect to fly the helicopter during the mission without adjusting the attitude indicator or you may mentally note the position of the horizon bar and adjust it for level flight. If the horizon bar is adjusted for level flight, it must be adjusted to the horizontal reference position prior to firing a flare rocket. Using this procedure, you are provided a horizontal reference from where the pitch attitude is measured for firing the rocket flare regardless of the load or configuration of the helicopter.

If a higher or lower height of flare ignition is required due to a difference in the terrain altitude between the helicopter and target area, the firing attitude should be increased 1° for each 200-foot difference in eleveation. For example, the standard 17° attitude for hover fire should be increased to 19° if the target is 400 feet above the firing point. Conversely, if the target is below the firing point, the pitch attitude for hover fire should be decreased 1° for each 200-foot difference in elevation (Figure 10-12).

If the target area can be seen, you can adjust for lateral corrections using the last flare

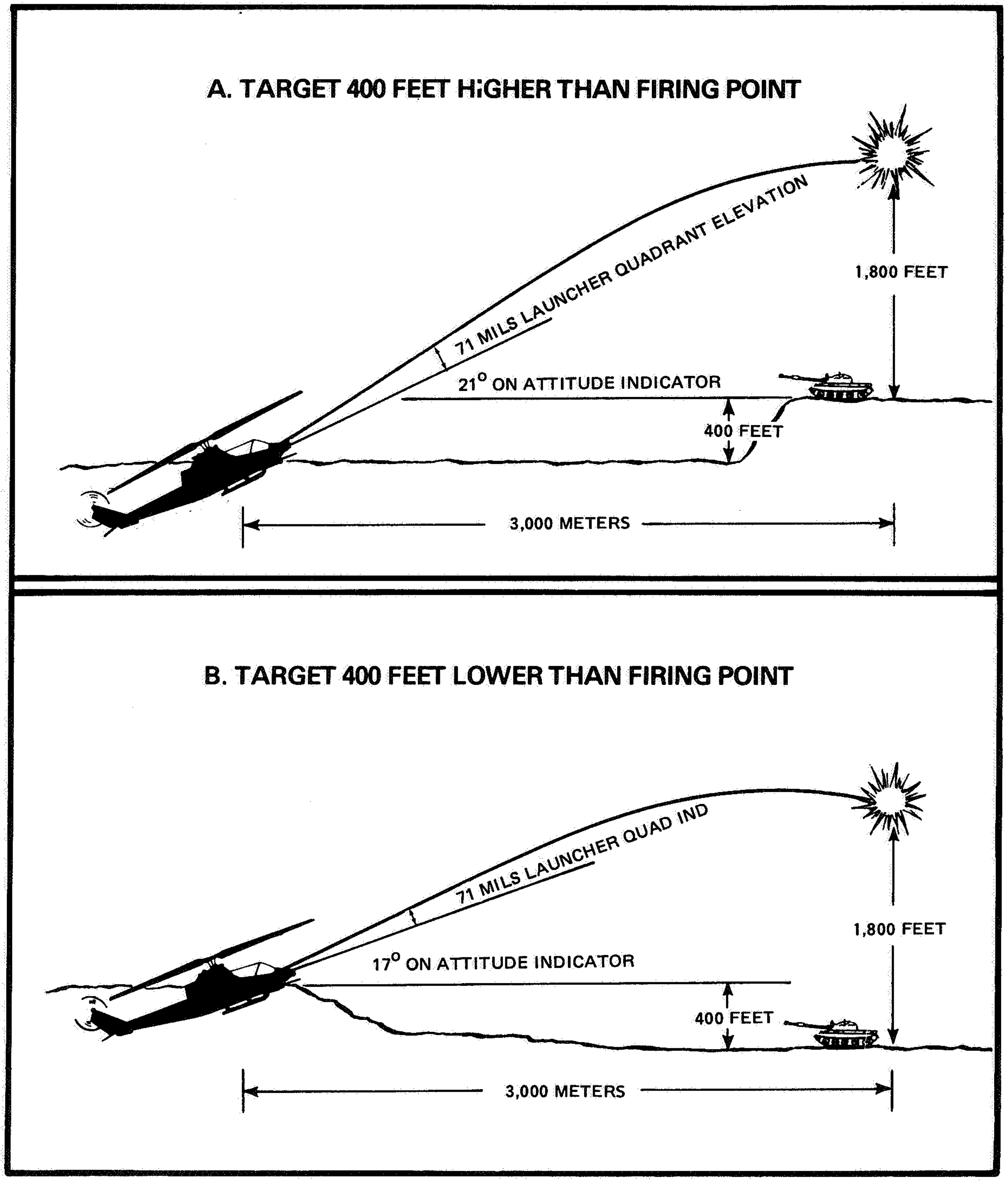

HOVER ATTITUDE = 5° NOSE LOW
RAISE NOSE 5° TO LEVEL HORIZON BAR WITH MINIATURE AIRCRAFT.
PITCH UP NOSE 15° TO ACHIEVE PROPER FIRING ATTITUDE, THEN FIRE.

210900-222-2

Figure 10-11. Attitude Adjustment for Desired Flare Ignition Height (Sheet 2 of 2)

fired as a visual reference. By viewing the flare through the gunsight, accurate adjustments can be made. Displacement of the reticle image (pipper) 10 mils right or left of the reference point will move the ignition point 30 meters laterally. When the target area cannot be seen, you must adjust the heading by reference to the heading indicator. A 1° change in heading will move the ignition point approximately 50 meters laterally (Figure 10-13).

Range corrections required to cause flare ignition over the target area are made by moving the firing point closer or farther from the target area. Corrections in range should not be made by changing the pitch attitude. Although a small change in horizontal distance will occur when the pitch attitude is increased or decreased, the primary effect will be a change in flare ignition altitude.


A. TARGET 400 FEET HIGHER THAN FIRING POINT

71 MILS LAUNCHER QUADRANT ELEVATION
21° ON ATTITUDE INDICATOR
1,800 FEET
400 FEET
3,000 METERS

B. TARGET 400 FEET LOWER THAN FIRING POINT

71 MILS LAUNCHER QUAD IND
17° ON ATTITUDE INDICATOR
1,800 FEET
400 FEET
3,000 METERS

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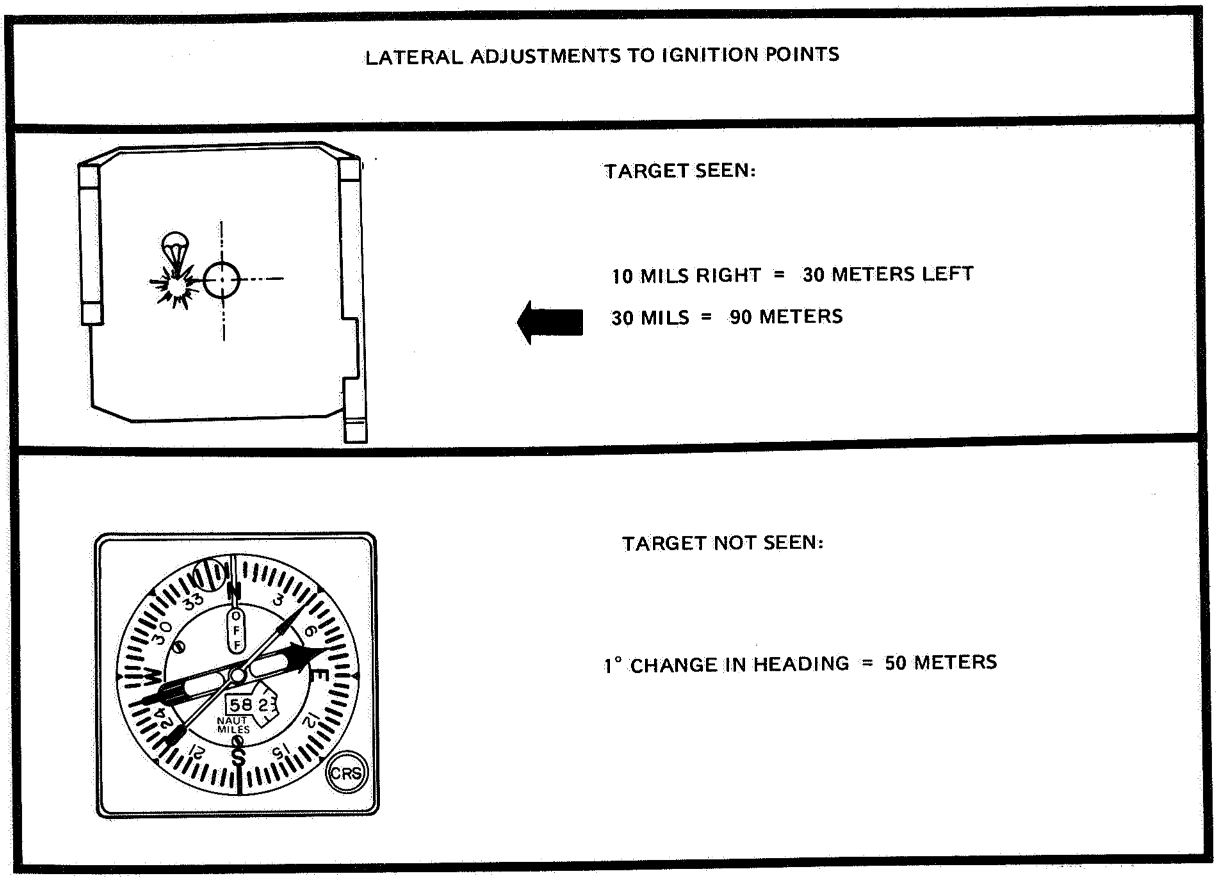
Figure 10-12. Flare Ignition Above and Below Firing Point


LATERAL ADJUSTMENTS TO IGNITION POINTS
TARGET SEEN:
10 MILS RIGHT = 30 METERS LEFT
30 MILS = 90 METERS
TARGET NOT SEEN:
1° CHANGE IN HEADING = 50 METERS
N
E
S
W
3
6
12
15
21
24
30
33
OFF
58
NAUT MILES
CRS

210900-224

Figure 10-13. Lateral Adjustments to Ignition Points

When required to maintain continuous illumination over a target area, you must first determine the number of ignition points required for proper illumination. For spacing between ignition points to maintain a 0.2-foot candle illumination over the linear target area, approximately 14° heading change is required between firings when using one flare at each ignition point. If two flare rockets are used at each ignition point, a heading change of 20° is required to achieve the desired spacing for the same illumination over the target area. After the first flare rocket has been fired, turn the helicopter to the proper heading while maintaining the same firing position, and fire. A rocket flare must be fired every 45 seconds at each heading until the requirement for continuous illumination no longer exists; supply of rocket flares has been depleted; or the firing position is untenable.

10.8.6.3 Running Fire. A second delivery technique used for firing the flare rocket is running fire. This technique has the advantage that less power is required and the helicopter is more stable when firing. It has the disadvantage that the helicopter must be continually maneuvered at low altitudes while executing steep turns. Also, it is difficult to overfly the same firing point at night; thus reducing the accuracy that can be achieved.

The selection of a firing point is the same as discussed under hover fire. Once the firing point has been selected, you must determine the pattern that will be flown. The rate of turn and the time of the outbound leg are determined by the time interval between firings and the number of helicopters available to fire. A single helicopter illuminating a target with one ignition point must fly a circular pattern to maintain an interval of 45 seconds between firings. If two helicopters are available, a racetrack pattern can be flown. To maintain the desired time interval between firings, the helicopters should be positioned 45 seconds apart within the pattern. (Figure 10-14.)

Note

> A target requiring multiple ignition points cannot be illuminated with one helicopter using running fire. When multiple ignition points are required, each helicopter should establish separate firing points.

To achieve the desired flare ignition height, it is necessary to elevate the launcher 28° above the horizontal reference. To do this, a 22° pitch attitude is required. This attitude is based on a launcher quadrant elevation of 105 mils (6°) and an airspeed of 60 knots. Additional adjustment to the pitch angle would be required for speeds varying from 60 knots. The procedures required to achieve the desired firing attitude and correction for lateral error and range error are the same as discussed in hover fire. (Figure 10-15.)

10.8.6.4 Wind Drift. Until the flare warhead deploys, the effect of the wind is acting upon the rocket. After flare ignition, the effect of wind is acting upon the flare. When firing into a crosswind, the aircraft heading must be aimed upwind so that the burntime of the flare rocket will be equally spaced over the target area. When the parachute opens, the flare will drift at approximately the speed of the wind. To determine the proper upwind correction for a crosswind, it is necessary to know the windspeed and direction at the altitudes where the flare will be burning. Normally, the only available wind information, will be forecasted

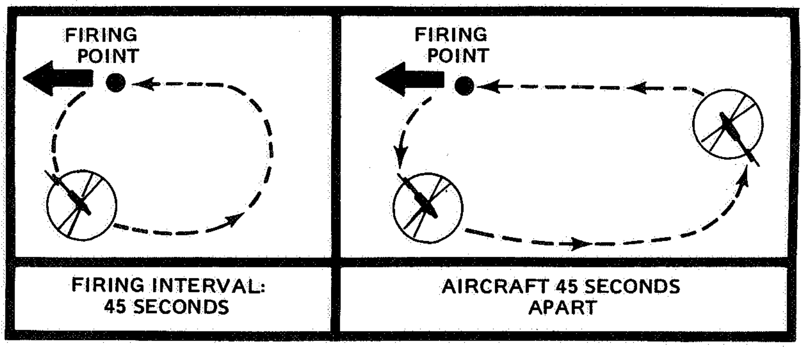


Figure 10-14. Running Fire Patterns

conditions. Using this information, the pilot applies the rules of thumb that for each 10 knots of wind, a correction of 300 meters or a heading correction of 6^{o} is required. After the first round has been fired, the pilot can make more accurate corrections based on actual wind conditions.

10.8.6.5 Tactical Considerations

1. The number of flare rockets that an attack helicopter will carry is determined by the mission and the helicopter weapons configuration. Unit SOPs should be established designating the payload for each aircraft. A single helicopter designated for flare rockets is least desirable because the illumination capability is lost if the helicopter is destroyed by hostile fire or if it experiences maintenance difficulty.

2. To minimize detection by enemy acquisition devices, the flare rocket should be fired at terrain flight altitudes.

3. To ensure continuous illumination over the target, flare rockets must be fired at 45-second intervals. Using this time interval, the aircrew has sufficient time to fire a second flare rocket before flare burnout in the event of a flare malfunction.

4. The helicopter firing the flare rocket should be positioned so that the users are between the flare helicopter and the target. When this cannot be achieved, the flare helicopter may fire from the flanks. A firing position between the attacking helicopters and the target should be avoided.

5. The center of the ground illumination pattern should be positioned behind the target as viewed by the engaging force. This technique enhances target detection by silhouetting the target against the high-intensity light as opposed to the dark contrast of the outer illumination boundary.

6. Although the primary mission of the flare rocket is to provide illumination for combat action, it can be effectively used as a signaling device or as a reference for air navigation. Each mission must be coordinated with ground units that will be affected by the illumination to ensure timeliness and accurate location of where the flare rocket will illuminate.

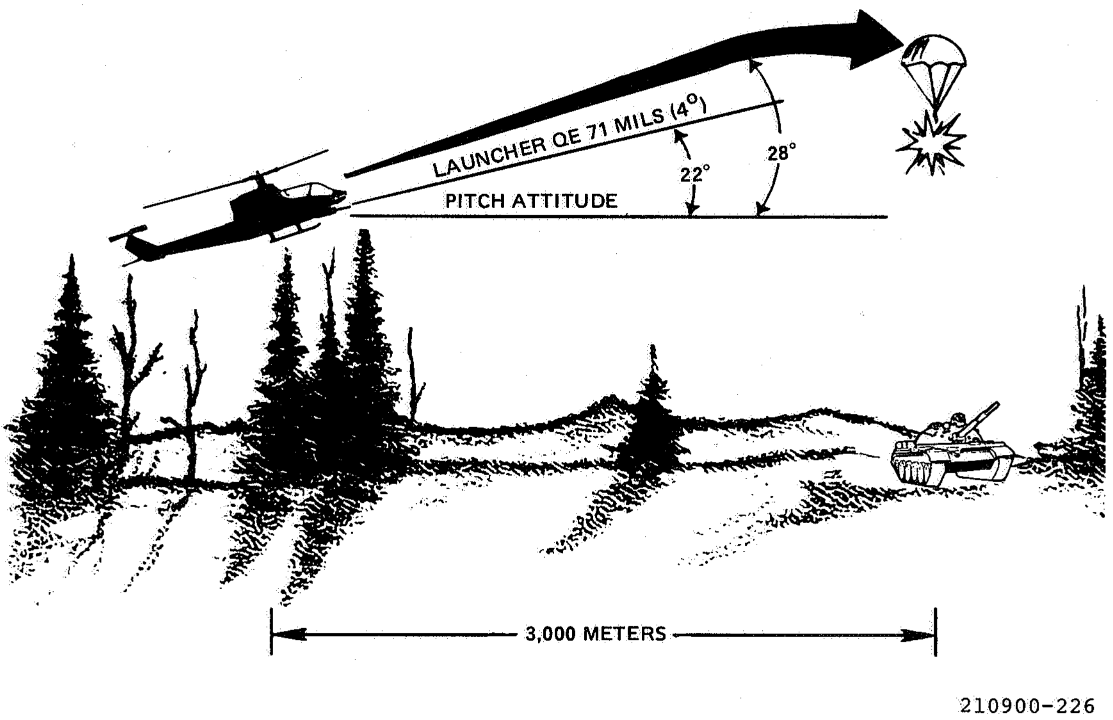


Figure 10-15. Running Fire Pitch-Up Degrees

CHAPTER 11

Employment of TOW Missile

11.1 GENERAL

The AH-1T may be configured with conventional ordnance in order to accomplish all tasks associated with attack helicopter operations. The TOW missile system, with its unique point target accuracy, provides for a variety of applications in support of tasks other than antiarmor destruction. Methods of using this capability will be identified under each task, but they are not limited to those recommended. The techniques and considerations for employment remain the same as for the antiarmor role that is discussed in detail in this chapter.

11.1.1 Armed/Convoy Escort. A TOW-configured aircraft has a limited capability for fire suppression with conventional ordnance; therefore, it should not be used to escort transport helicopters in the traditional manner. Separate TOW sections can be effectively employed in conjunction with the escort role to provide the following support.

1. Destruction/neutralization of AAA and SAM systems as may be practical. Careful consideration should be given to this employment, but only when the terrain and tactical situations are not prohibitive.

2. Denial of enemy mechanized assets near a friendly unit's landing zone or axis of advance.

3. Destruction of enemy observation posts, bunkers, and communication facilities when these fortifications may allow for early observation and response to friendly deployment.

4. Engagement of enemy helicopters at extended ranges when that threat might interrupt deployment by either observation, fire support, or troop transport.

11.1.2 Aerial Fire Support. The accuracy of the TOW missile system (TMS) allows for engagement of specific point targets with a high probability of kill previously unattainable. Exploitation of this point-target capability should be efficiently used whenever possible. The desired method for this use is preplanned missions. In aerial fire support missions, TOW may be employed in order to:

1. Destroy shore emplacements, machine-gun positions, and barriers that may impede friendly offensive movement.

2. Destroy artillery, communications vans, and radar sites that are mobile and difficult to identify and destroy.

3. Disrupt the enemy's logistic support efforts by engaging mobile convoys, trains, and boats as well as certain bridges and tunnels.

11.1.3 Suppression of Enemy Air Defense (SEAD). In a SEAD mission, TOW may be used in both an offensive and defensive capacity to facilitate employment of high-performance aircraft. While the TOW missile does not possess a target marking capability, it may be used to:

1. Compliment high-performance pop-up attacks by engaging AAA/SAM systems and radar sites either prior to or concurrent with the attacking run.

2. Provide some defense against enemy armed helicopters at extended ranges.

3. Observe the target area from extended ranges using 13x optics, while denying the enemy warning of the impending action.

11.1.4 Visual/Armed Reconnaissance. The characteristics of the TSU in both 2x and 13x optics provide for observation of an area at extended ranges. This capability negates the need for the aircraft to fly over hazardous areas which may not be survivable and reduces the possibility of compromising friendly movement and intentions. While this is not the most effective use of the AH-1T, certain situations may dictate implementation. Detailed reconnaissance techniques are contained in Chapter 9.

11.2 CAPABILITIES/LIMITATIONS

11.2.1 Capabilities. The AH-1T can be configured to carry eight TOW missiles. In this configuration, the LAU-68 pod may be carried on the inboard station. With four missiles, a variety of other types of ordnance may be carried on the inboard stations. The TOW missile receives commands from two wires attached to the launcher tubes. These commands are based on infrared signals from the missile to the aircraft. The maximum effective range of the TOW missile system (TMS) is 3,750 meters, and the minimum range is 500 meters. Time of flight versus range is depicted in Figure 11-1. The absolute maximum time of flight is 21.5 seconds. Wirecut from the missile will occur under the following conditions:

1. When the IR signal is interrupted for 0.5 second by an obstacle between the missile and the aircraft

2. Upon target impact

3. When manually initiated by either pilot or copilot

4. When either wire is inadvertently broken

5. After 21.5-seconds time of flight has elapsed.

The TOW missile was primarily designed for armored vehicles, but is also effective against other point targets. All launchers can be reloaded in a very short period of time.

The TMS can be used in the hover and running modes of fire. Because of the tracking problems associated with the running mode of fire, it is considered to be more accurate and survivable to employ the TMS in the hovering mode. When using the diving mode of fire, the likelihood of wire wrap is increased, and while this presents no known aircraft control problem, it should be avoided.

Missiles may be fired in either a manual or an automatic mode. In the automatic mode, the impact of the first missile will automatically initiate the firing of a second if the trigger remains depressed.

A 13x telescopic sight unit (TSU) is associated with the TMS which enables the gunner to see targets at extended ranges. The TSU is aligned with the desired target by use of the sight hand control (SHC). In the TSU/gun mode, the turret is slaved to the TSU and provides for the delivery of extremely accurate 20-mm fire. The TSU will traverse 110° on either side of aircraft centerline, 30° in elevation, and 60° in depression.

Note

Turret depression limit is 50°.

When operating in the low-magnification position, a circle is displayed on the sight reticle. This circle represents the field of view on high magnification. This is to be used by the gunner to determine when he can transition to high magnification. The TSU sight also has three status indicators. The ATTK indicator illuminates when the high-magnification position is selected, a missile is present, and the action bar is depressed. The RDY indicator illuminates when the aircraft is in prelaunch

METERS	SECONDS
3750	21.5
3000	15.0
2000	8.8
1000	4.0
500	2.0

Figure 11-1. TOW Missile Time of Flight

constraints. The GUNS indicator illuminates when TSU/GUNS has been selected in the TOW control panel (TCP).

The helmet sight subsystem (HSS) allows both the pilot and gunner to fire the turret and to acquire targets for the TSU. While using the HSS, forward-firing ordnance may be employed as a 1.5-second lockout (lower stow) occurs prior to and after launch. The inboard stations cannot be used when firing the TMS; however, the turret may be fired both prior to or after TOW launch.

11.2.2 Limitations. Line of sight must be maintained between the missile and the aircraft. Failure to do so will cause wirecut. All suppressive fires must be planned so that smoke does not obscure the target or interrupt line of sight. Additionally, an excessive slew rate by the TSU may place the missile out of the field of view for the IR seeker, thus causing automatic wirecut. This becomes increasingly important at extended ranges as the field of view becomes narrower.

The greater the range, the more ineffective the shaped warhead's penetration capability. This is because of the high angle of attack the missile must achieve to maintain flight. The greater the angle of impact, the shorter the penetration.

Employment of the TMS near friendlies can result in several problems. First, wire from the TOW missile can present a hazard to both vehicles and personnel. Second, close attention must be paid to blast effect. This blast effect becomes increasingly important as operations in and among ground forces become fully integrated.

The time of flight of the TOW missile, when combined with initial target acquisition, may result in a total aircraft exposure time that is prohibitive. There may be an increase in both of these factors at ranges in excess of 3000 meters. Subsequent sections on employment address methods for offsetting this disadvantage; their understanding is absolutely essential if maximum survivability is to be achieved.

The field of view as observed through the TSU is limited to 28° in low magnification (2x) and 4.64° in high magnification (13x). This serves to make the initial target acquisition capability difficult in low magnification and virtually nonexistent in high magnification. Use of the HSS, the terrain, and other visible recognition features for initial TSU orientation is essential if exposure time is to be effectively reduced. This limitation is further aggravated during low-light-level periods that occur when visibility is affected by weather phenomenon. Rain alone can spot the TSU making high-magnification operations difficult.

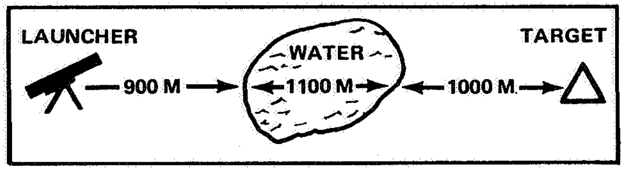
The HSS is mounted to each pilot's helmet and sighted to his eye. If a pilot has not had the HSS and helmet boresighted, accuracy is degraded.

11.2.2.1 Wire Wrap. In high-power diving flight, the aircraft can overrun the guidance wires, resulting in a wire-wrap around control tubes, rotor hubs, and other control surfaces. No control degradation has been experienced; however, possible damage to garlock seals, control bearings, and other dynamic hardware can result. For this reason, high-power diving delivery should be avoided. If diving flight is tactically required, power settings below 40-percent transmission torque should be used, and the aircraft should be inspected for possible wire wrap as soon as possible.

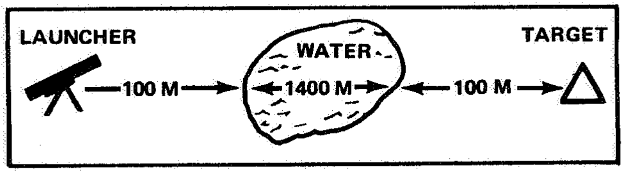
11.2.2.2 Wire Entanglement. The guidance wires settle at approximately 8 feet per second. In high-speed forward flight, the aircraft will overrun the wire and produce a catenary below and behind the launcher. At low altitude, it is possible that the guidance wire can become entangled on trees, rocks, and other obstacles. The flightcrew should be aware of wire entanglement possibilities in low-altitude, forward-flight conditions. The terrain characteristics and obstacles along the flightpath should be evaluated to avoid wire entanglement. Wire entanglement can result in wire breakage which will terminate missile guidance.

11.2.2.3 Tow Missile Guidance Wire Emersion Limitations. The TOW missile system is range limited when fired over fresh or salt water. Capacitive coupling between the signal wire and ground caused by the high dielectric coefficient of water (80), as compared to air (1), shorts the signals sent by the launcher before they can arrive at the missile. Fresh or salt water produces the same results.

The missile may be fired over water to maximum range as long as the distance the wire is submerged across the water does not exceed 1100 meters:



For bodies of water larger than 1100 meters, the launcher or target must be near the water edge, and the total range must not exceed 1600 meters:



If the TOW launch position or target can be elevated above the surface of the water, the range to the target can be increased as shown in Figure 11-2. This assumes the case where the launcher and target are both located on or near the water.

Example calculation (refer to Figure 11-2).

Problem: An AH-1T (TOW) is 50 feet (16 meters) above the water and wants to attack a gun boat across open water.

Solution: Draw a line from left margin of Figure 11-2 launcher height at 16 meters to the right margin target height. Read the answer from center scale.

Answer: The missile has a range less than 2500 meters.

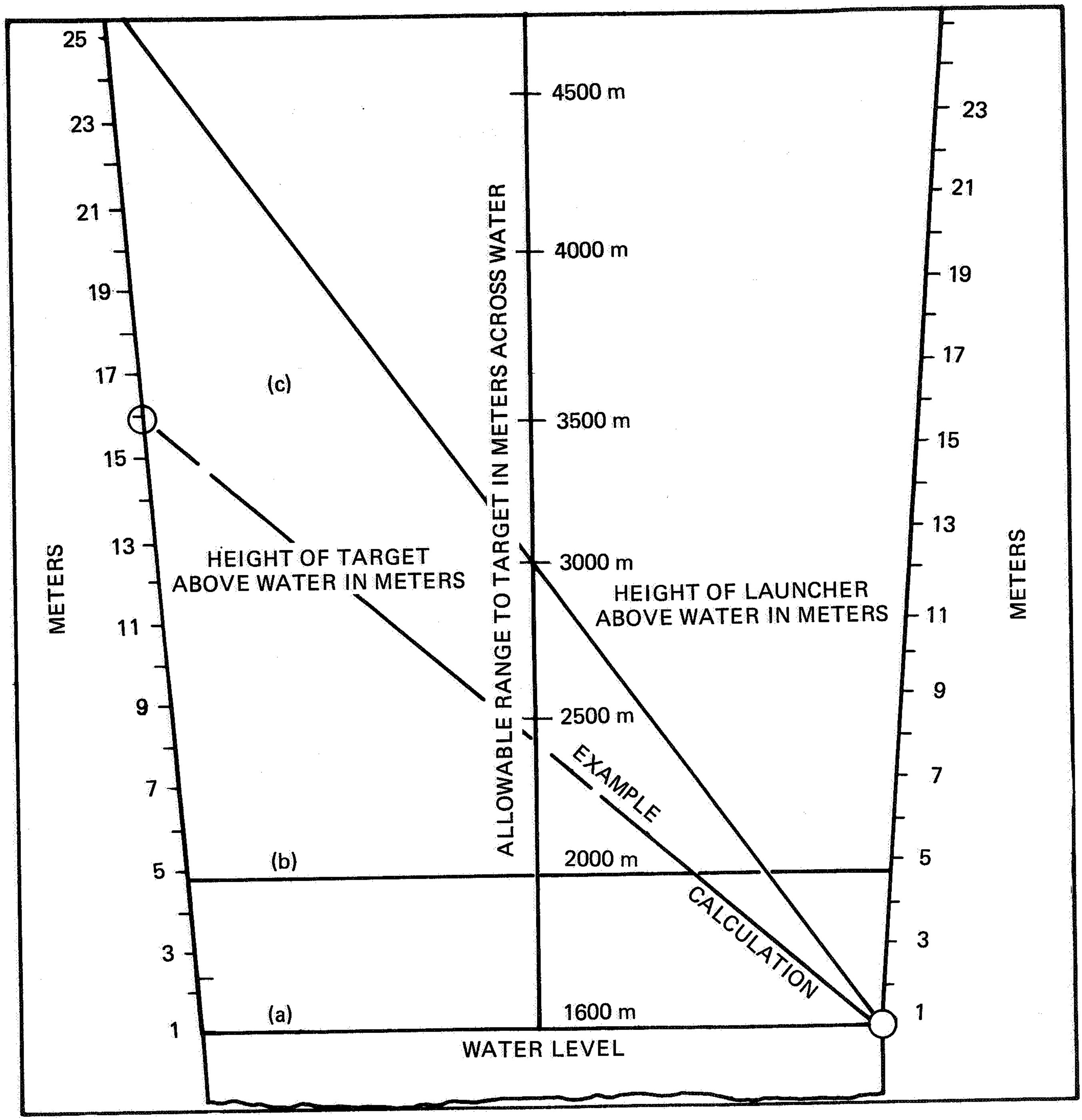


Figure 11-2. TOW Over Water Limitations

11.2.2.4 Overwire Performance of the TOW Missile. There is very little information on possible performance degradation of the TOW missile due to guidance wires contacting electrical wires. No known firings have been conducted; however, some limited analytical data is available. If the guidance wire contacts electrical wires with line voltages between 100 and 25,000 volts, there will probably be no performance degradation as long as the guidance wires do not contact the earth or some other electrical ground. If the guidance wires contact a ground, the current produced will burn the wires. Above 25,000 volts, induced current in the guidance will burn the wires. As currently understood, there is no safety hazard to the crew or the aircraft as a result of contact between high-voltage electrical wires and the missile guidance wires.

11.3 SYSTEM OPERATION

The manner in which the cockpit is set up for tactical operation will depend to a large extent on whether the TOW is to be employed or whether the turret/HSS combination is to be used. In all cases, the degree of response desired and other required gunner responsibilities are key factors. A complete discussion of switchology, crew coordination, prelaunch and postlaunch constraints, and tracking procedures comprising the engagement cycle may be found in the AH-1T NATOPS Manual.

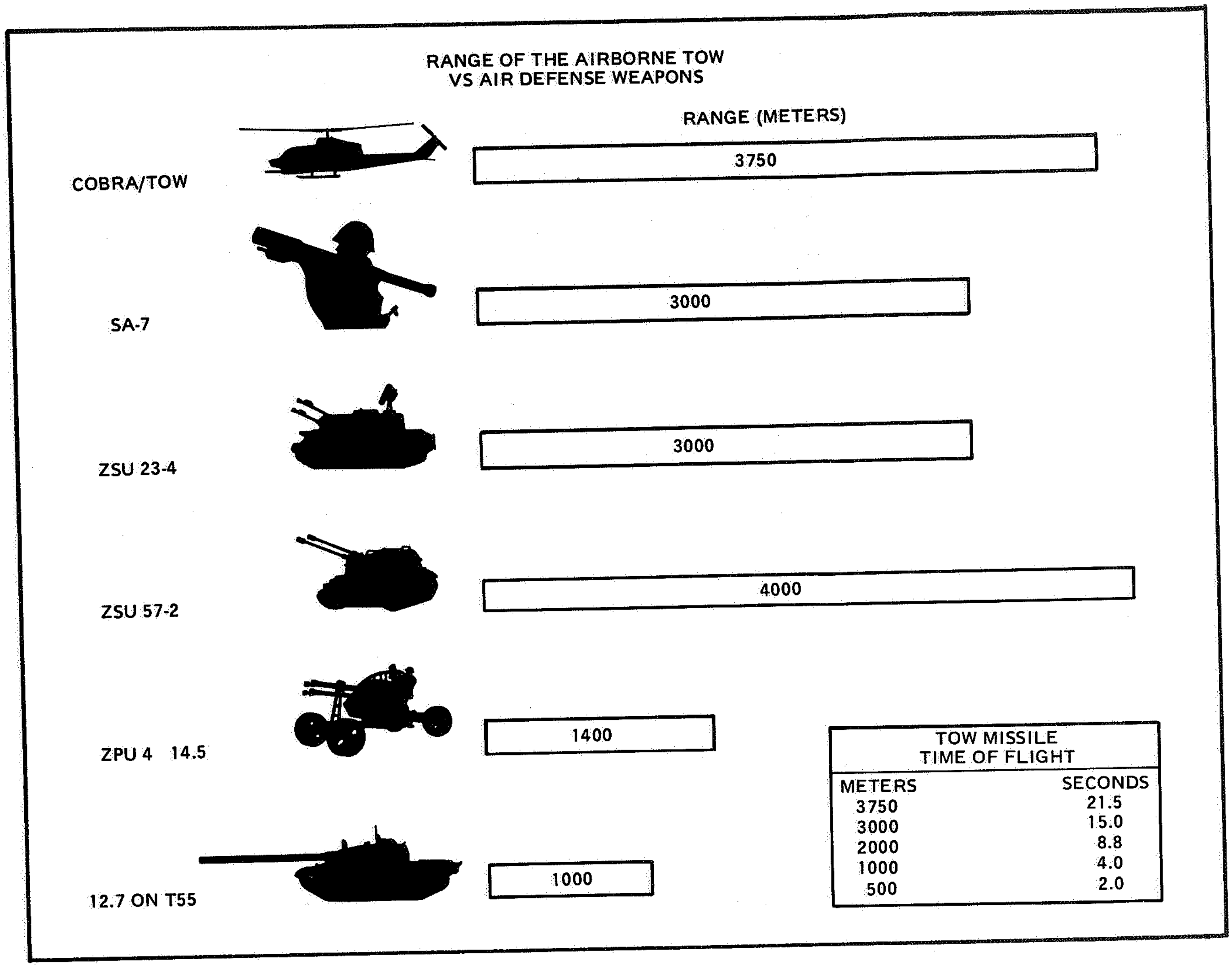
11.4 TOW EMPLOYMENT

The high missile reliability, an extremely accurate control system, and a potent warhead combine to make the TMS an extremely lethal weapons system against all known armored vehicles. Those same qualities also give the TOW the ability to provide the AH-1T with a true point-target attack capability. The system alone, however, must be fully understood and carefully employed if these capabilities are to be fully realized. In planning and executing TOW operations, there are four rules, when applied to a sophisticated threat environment, which enable the AH-1T to exploit the enemy while enhancing survivability.

11.4.1 Standoff Use. Every effort should be made to maximize standoff advantage. For example, the probability of survival against a combination of all threat ADA systems found at the regimental level increases from 50 percent at 2500 meters to 92 percent at 3000 meters, assuming a 63-second exposure time. The probaiblity of kill for the TMS decreases with increased range. The optimum ranges for engagement with the TMS are between 3000 to 3500 meters. This provides for the greatest aircraft survivability without seriously degrading the effectiveness of the TOW missile system. It should be reiterated that survivability is keyed to the distance from the ADA systems. Figure 11-3 graphically displays TOW standoff ranges in comparison to current threat systems.

11.4.2 Minimum Exposure. The longer an aircraft remains exposed, the greater the changes of being engaged by ADA systems. Exposure time is a function of acquisition, engagement sequence, and time of flight. Since time of fight is a system characteristic and cannot be altered, the target acquisiton and engagement times must be kept to an absolute minimum without adversely affecting TMS accuracy. The engagement sequence can be reduced only by training and standardization. Although the crew concept may be ideal, it may be impractical. Common terminology and procedures must be instituted and standardized. The single greatest contributor to excessive exposure times will be target acquisition, particularly at extended ranges. This may be reduced through precise target briefs, crew sectors of observation, and target marking. Generally, if exposure exceeds 30 seconds without acquisiton, consideration should be given to remasking and moving to a more advantageous observation point.

11.4.3 Terrain Use. The proper use of terrain can often offset the disadvantages of exposure time and engagements within the effective range of ADA systems. From a defensive



TOW MISSILE TIME OF FLIGHT

METERS	SECONDS
3750	21.5
3000	15.0
2000	8.8
1000	4.0
500	2.0

Figure 11-3. Range of Airborne TOW Versus Air Defense Weapons

aspect, terrain and vegetation may provide both cover and concealment, ensuring that the attack is not compromised. It may also provide for immediate protection should the enemy engage friendly aircraft. Offensively, it may be used to channelize armor, impede the enemy's movement, and restrict the fields of view for accompanying ADA. The kill zone for an attack must be determined by placing the enemy in the worst possible position while maintaining an advantage for the attack.

11.4.4 Concurrent Employment of Supporting Arms. Artillery, high-performance aircraft, and naval gunfire can have a distracting, if not devastating, effect on an armor column and its air defense. Although careful planning and precise execution will be necessary, every effort should be made to engage enemy targets with other supporting arms concurrent with the TMS. Every known AAA/SAM system currently deployed is vulnerable to artillery. High-performance aircraft not only may deliver destructive ordnance, but may also serve to saturate air defense radars and confuse controlling systems. Obscurants may be employed to deny air defense observation of attacking aircraft. However, careful consideration should be given to avoid obscuring the target. This may require a dedicated AH-1 to control the supporting arm, but the increase in survivability will more than offset the initial dedication of that aircraft.

11.5 PLANNING — ANTIARMOR ROLE

11.5.1 Analysis of METT. Before any serious planning can begin for an assigned mission, a thorough analysis of those factors that will affect mission success must be conducted. The acronym METT provides an outline for the mission commander to follow in his initial analysis.

11.5.1.1 Mission. A mission may be subdivided into two parts: assigned and implied missions. Assigned missions are more readily apparent, as they are generally indicated on the frag order. Implied missions must be deducted from the assigned mission. For example, to engage armor with a covering ADA system, the ADA must also be engaged.

There are also two types of missions generally assigned to Marine aviation: preplanned and immediate. Preplanned missions have historically been characterized as those missions directed against targets that can be anticipated sufficiently in advance to permit detailed mission coordination and planning. Immediate missions, on the other hand, are requests against targets that could not be identified sufficiently in advance. The AH-1T may be used to support either of these two types of missions or a combination of both. In support of a battalion's antimechanized plan, the squadron's operations department should provide for the necessary reconnaissance, planning, and coordination. However, the execution of the mission may be delegated to those aircrews assigned on a standby basis. Thorough and detailed planning is essential in light of existing ADA capabilities if unacceptable losses are to be avoided.

The antiarmor task is just one of the several tasks assigned to marine attack helicopter squadrons and can be characterized as either offensive or defensive in nature.

Antiarmor defense includes the AH-1T into the overall antimechanized posture. The countermechanized plan to the ground unit's operation order defines the specific missions to be assigned the AH-1 force. Defensive missions are generally conducted in the security and battle areas of a unit's area of responsibility and are short of the fire support coordination line (FSCL). This implies that the concurrent planning and coordination between all units be continuous and detailed. The characteristic speed and maneuverability of the AH-1T may not be a factor in the use of the system because of the density and proximity of friendly forces. Armed reconnaissance and retrograde support operations may also be considered defensive actions. Coverage of antimechanized barriers may also be considered, particularly on the flanks and between gaps in the friendly force's lines of defense.

Antiarmor Offense involves those actions in support of friendly units maneuvering against the enemy. This role capitalizes on the speed, maneuverabilty, and flexibility of the AH-1T either forward or on the flanks of rapidly advancing friendly forces. It is possible that offensive operations may be conducted forward of the FSCL, therefore eliminating a degree of coordination external to the flight. This will allow for a more responsive engagement using assets within the flight against targets of opportunity. The extended ranges that may be associated with an advance by friendly forces must be carefully weighed against logistical support capabilities. Convoy escort, exploitation, pursuit, and antiarmor ambushes are other examples of offensive actions.

11.5.1.2 Enemy. Effective employment of the AH-1T cannot be achieved until a thorough knowledge of the opponent's equipment and tactics is understood by each member of the flight. The order of battle for an opposing force details the composition, organization, location, and methods of deployment in both the offense and defense. The weaknesses in systems and tactics must be identified and exploited to the maximum. It is more important to know what he cannot do to you, than what he can do to you. As the battle progresses, there may be changes in the enemy's method of war. Thorough debriefs and trend analysis can allow for early detection of new equipment and tactics. The capabilities for updating battlefield intelligence must be fully realized and the widest dissemination received. A variety of charts and maps should be maintained by the squadron intelligence section. Examples are as follows:

Situation maps debrief the dispositions of both friendly and enemy units with overlaps depicting AAA/SAM ranges, MIJI status reports, enemy air activity, reported artillery concentrations, and losses to AAA/SAM and small arms. Areas and routes that are frequently being used by friendlies should also be monitored.

Hazard maps depict the obstacles that may be encountered while flying at terrain flight altitudes. Of particular importance are wires, bird concentrations, and other obstacles that are difficult to see from the air. Hazards must be continually updated and briefed to the aircrew, as they may play an important part in route selection.

Terrain maps should be constructed by layer tinting or other methods to highlight terrain that may be used to mask a flight. Vertical as well as horizontal consideration should be displayed. Recommended zones for low level, contour, and NOE flight should be portrayed as compared to the enemy threat.

Going maps are specifically related to the antiarmor role and are designed to indicate where trafficability is well suited for armor, mechanized, and wheeled vehicles. They may also be used in conjunction with terrain maps to determine ambush sites and kill zones. Speed charts can also be made to determine average speeds over areas of varying trafficability.

11.5.1.3 Terrain. With the sophisticated threat systems now available worldwide, the techniques of terrain flight were introudced to allow aircraft to work under usable enemy radar and engagement envelopes. Terrain may therefore play an increasingly significant role in the planning of future operations and must be used to the optimum to decrease detection and increase survivability. The altitude to be flown will usually be determined by the threat. The airspeed will be directly affected by the terrain. Formations are also specifically affected by the impact of the terrain to the point where certain formations may be impractical. Battlefield organization must be established based upon the terrain as used by the pilot. Holding areas, attack positions, coordinating measures, and their alternates must provide concealment and should provide some degree of protection. All must be oriented on the terrain. Unfavorable terrain such as swamps, rivers, and impassable mountains may be used to anchor flanks and provide frontal/rear security from surprise attacks. In all cases, the recent traffic in a given area should be carefully considered to avoid compromising the terrain and negating its positive effect.

11.5.2 Mission Receipt. Preplanned, scheduled, and on-call missions in support of both offensive and defensive operations will be identified by frag order to the squadron. Contact should immediately be established with the requesting unit to ensure involvement in the planning stage. While it is certainly desirable that the flight leader assigned the mission establish liaison, it may be impractical. It should therefore become the responsibility of the operations officer to provide a qualified officer for mission planning. This is particularly important when the ground unit is formulating its countermechanized plan. Normally, the preplanned mission will identify the unit being supported, the dates and times of support, the desired support, and point of contact.

Immediate missions, however, may require modification of the detailed planning cycle by the flight leader. Any mission should include the following information:

1. Number and type of targets
2. Last known location and time
3. Direction and speed of movement
4. ADA type and location within the force
5. Enemy helicopter/fixed wing (if applicable)
6. Friendly supporting arms in support
7. Unit receiving support (if applicable)
8. Time on target (if applicable).

11.6 BATTLEFIELD ORGANIZATION

Most attack helicopters will be based well behind the FEBA if not aboard amphibious shipping. As response times become more critical, the attack helicopters may be deployed ashore. Battlefield organization is designed to emplace the TOW team as close to the kill zone as may be required without compromising the action or unnecessarily endangering the flight. As the attack becomes imminent, the closer attack helicopters are deployed forward. Effective organization of the battlefield is best accomplished by planning backwards from the kill zone to the most forward site. Control measures and areas may be deleted in order to assure that the firing points are manned at the designated time for the attack.

11.6.1 Establishment of the Kill Zone. The engagement area is that area forward 500 meters from the firing point out to 3750 meters. The safe engagement area is that area forward approximately 2000 meters from the firing point out to 3750 meters.

Note

> TOW engagement ranges may be extended through the use of running fire (1 KTAS = .51 meters per second).

The kill zone is that area covered by the collective engagement of all areas of all TOW aircraft, where the enemy forces are to be killed. Terrain will be the greatest determining factor in the selection of a kill zone because:

1. The enemy armor formation is to a large part restricted by the trafficability of the terrain.
2. It is desirable that firing points be selected to provide cover and concealment.
3. Terrain can channelize the armor column, increasing its vulnerability by restricting its observation and mobility.

There are usually three types of target layouts, each dictated by the operational terrain.

A frontal engagement (linear target) is used in generally open country with multiple routes or axis of advance. Figure 11-4 depicts this type of target/attacking aircraft relationship. This terrain will require more aircraft than usual, as the distances between columns may preclude the engagement of any one column from a group of firing points. The alternative method of attack is to destroy a single column on either flank, and then work toward the opposite side. The obvious disadvantage is the

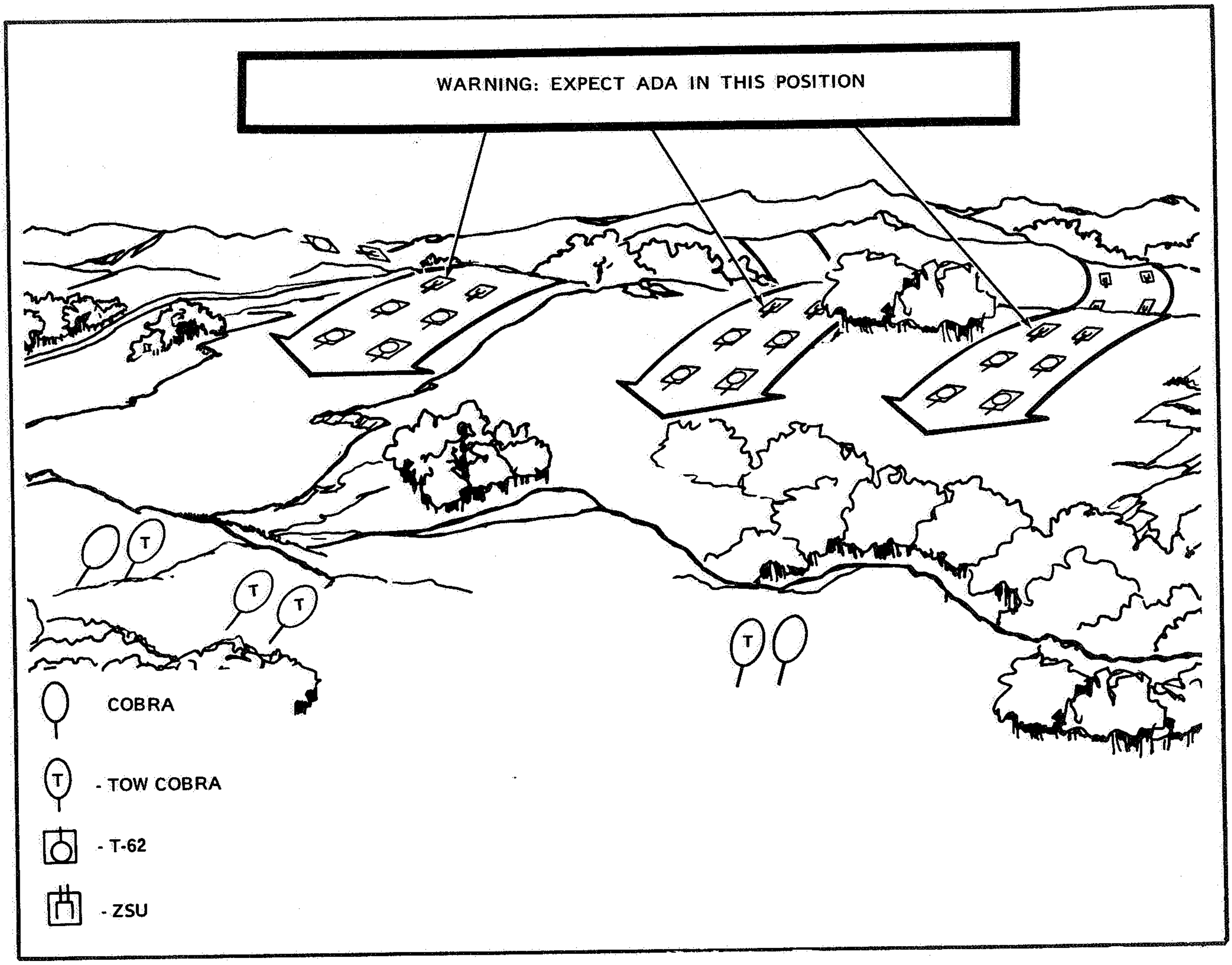


Figure 11-4. Frontal Engagement (Linear Target)

loss of surprise after the initial attack and the time involved. Whenever possible, avoid dispersing attack helicopters to the point where piecemeal commitment is dictated. Open terrain favors the enemy armor attack.

A frontal engagement (deep target) is formed when the terrain channelizes the enemy into a one-column formation. Figure 11-5 depicts the target/attack aircraft relationship. Although it is highly desirable that the enemy armor force be channelized, the attacking

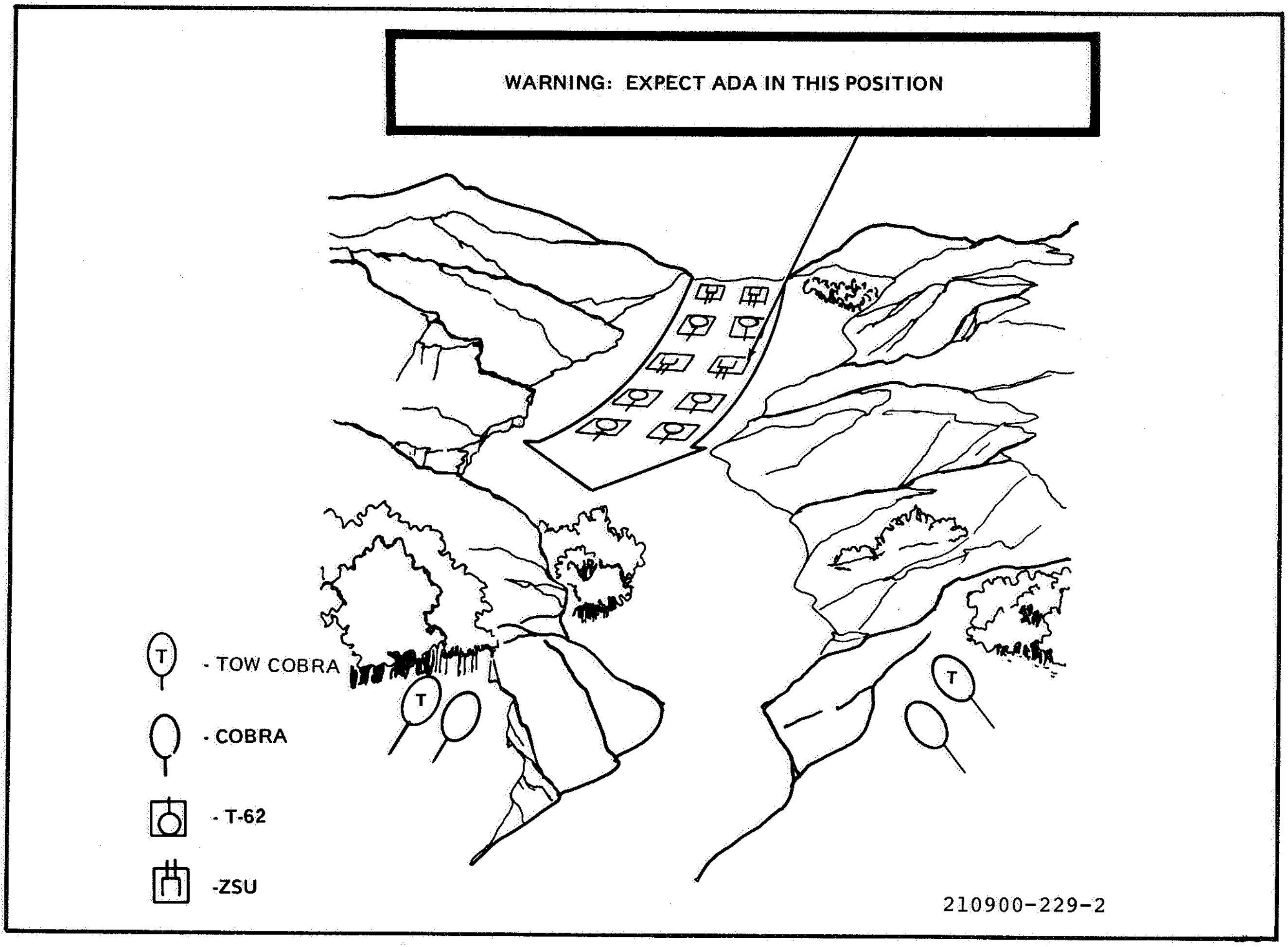


Figure 11-5. Frontal Engagement (Deep Target)

aircraft are positioned in such a way that only a few targets in the front of the formation can be engaged. Additionally, engagement is being conducted at the strength of the tank. If the terrain is too restrictive, the entire column could be stopped with the destruction of the lead tanks, and a more favorable attack reinitiated on the flank of the column.

A flank engagement is the most desirable target layout, as it provides the attacking aircraft with the more vulnerable side of the armor force, and when optimum terrain exists, a greater number of targets within a given area. Figure 11-6 depicts the target/attack

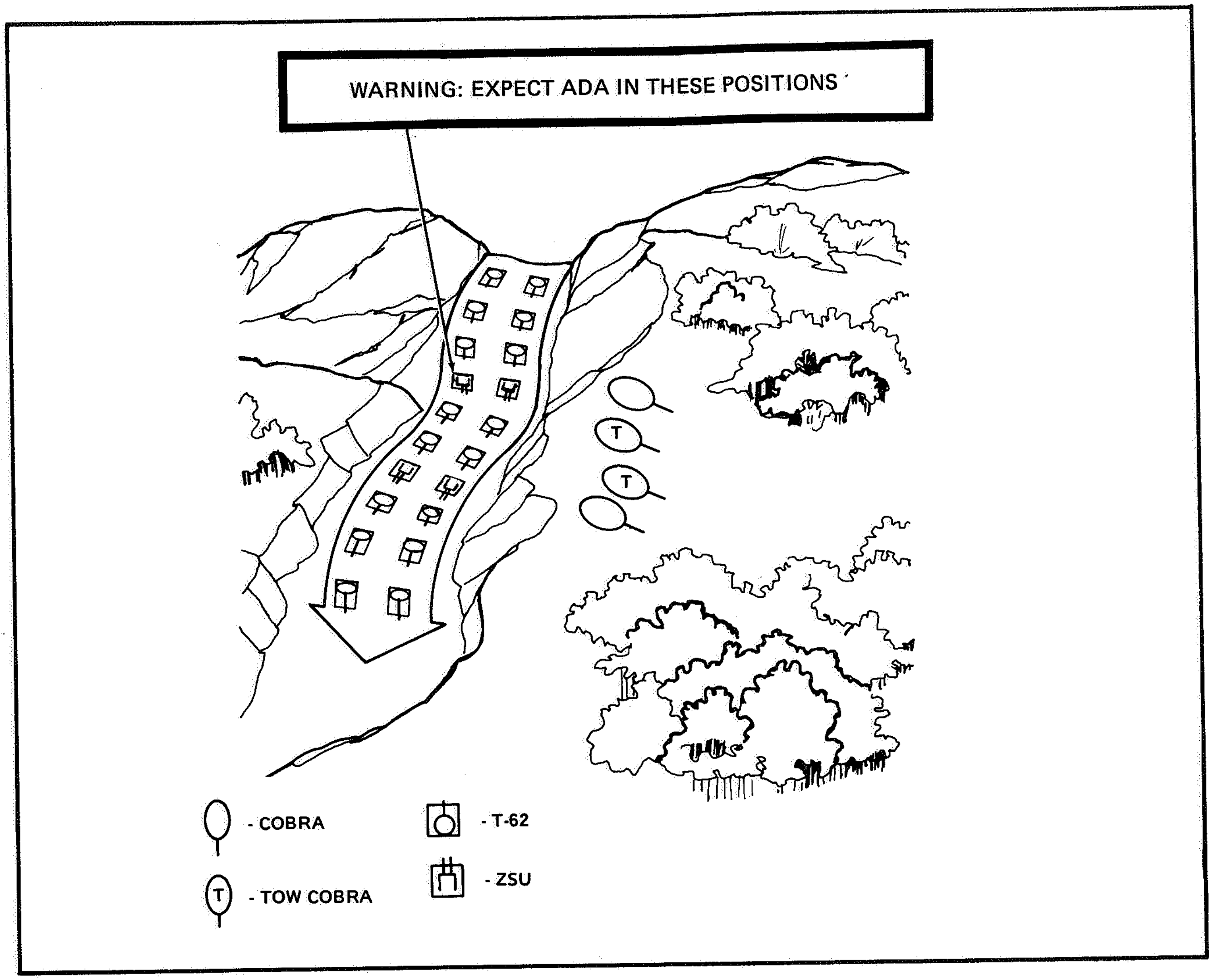


Figure 11-6. Flank Engagement

relationship. The priority of fires in this example should be the ADA and the leading armored vehicles in the column. Channelized as they are, the destruction of the lead armor would all but half the column.

The kill zone, therefore, should be established so that the safe engagement area coincides with the aspect of the column that presents the more lucrative target. Other factors that affect the establishment of a kill zone are:

1. Ability to respond to that area after initial warning in sufficient time to prepare for the ambush and prior to the enemy entering the kill zone

2. Desired axis of advance the ground commander wishes the enemy force to be channelized within

3. Maximum range of the TOW missile

4. Power lines and large bodies of water that may affect missile guidance

5. Concealed routes of ingress into the attack position

6. Availability of alternate attack positions/firing points

7. Location of friendly troops.

11.6.2 Firing Points (FP). Firing points are positions from which attack helicopters engage enemy targets. A minimum of one primary and one alternate firing point should be established for each attack helicopter involved in the attack. Firing points should provide for cover and concealment until unmasking is conducted and should allow each aircraft a measure of maneuverability. It is desirable that a backdrop be provided during unmasking, so that the attacking aircraft is not skylined. Firing points located in shadows make ground detection difficult and provide a dark background, which complicates aerial detection. Avoid dust, leaves, snow, and water as each becomes a compromising signature for a hovering helicopter. Avoid designating firing points close together, as this makes the enemy's acquisitions task that much easier, but not so far apart that visual signals cannot be seen. Ingress and egress to each firing point should be accomplished without exposure to preclude detection. A firing point should allow the gunner to engage targets throughout the kill zone and at the TOW missile's maximum range and safe engagement area.

Most firing points will be a compromise between all the desirable factors. In selecting firing points, the flight leader must be aware of the tradeoffs, and make those adjustments necessary to accomplish the mission in the assigned area.

11.6.3 Covering Points (CP). The prerequisites for covering points are the same as those for firing points; however, a few other characteristics are desirable. Covering points are used by the covering element in support of a TOW attack. Actions at the covering points are not restricted to firing, but may include mission control, supporting arms control, performance of deceptive maneuvers, and flank and rear security for the attacking element. Not only is it essential that the entire kill zone be viewed by a combination of covering points, but approaches to the kill zone must be observed as well. When targeting by other supporting arms occurs outside the kill zone, this sector must be observed from a covering point.

11.6.4 Attack/Egress Routes. The attack routes are the flightpaths that each aircraft travels from the attack position to its respective firing/covering point. The egress route is the path each aircraft takes from its primary to its alternate firing/covering points or to the rendezvous point (RP) after the attack is complete. Both should provide for cover and concealment, be accessible, allow for flight dispersion, and facilitate navigation. If a navigational error occurs, the aircraft should return to its last known point and reattempt to find its precise firing/covering point. Operations running parallel to the kill zone should be avoided, as this may compromise more than one firing/covering point. Egress routes should follow different paths than ingress routes.

11.6.5 Rendezvous Points (RP). After the attack has been completed, each section of aircraft must individually egress from its respective firing/covering point rearward. The rendezvous point provides a common landmark for all aircraft, enabling the flight leader to join up the flight. The RP should be located approximately the same distance from the kill zone as the holding area. It is recommended that the holding area not be used as an RP to avoid duplicity. At a given time or on some other prearranged signal, the flight will depart the RP to return to the holding area. If for any reason the attack is discontinued after departing the attack position, all aircraft should proceed to the RP. The RP should offer cover and concealment, be easily recognizable, and large enough to accommodate the number of aircraft in the flight.

11.6.6 Holding Area. The holding area is an intermediate position between the flight's point of origin and the attack position. It is used to hold aircraft short of the attack position in the event of mission change or timing errors. It allows the TOW team to be displaced as far forward as possible in anticipation of immediate operations. For these reasons, the holding area should have a communications network no less extensive than that found at the regimental level to facilitate coordination. The holding area may also provide emergency fuel and ordnance stocks. It is preferred that the holding area be outside enemy light artillery range and possess an intelligence update capability.

11.6.7 Control Measures. The timing of a TOW attack is critical if exchange rates are to be favorable. This is further complicated by the various supporting fires and action that may be employed. It is therefore important that extensive control measures be used to ensure the desired final coordination at the kill zone. Given the limitations of radios at terrain flight altitudes and the dispersion that will be inevitable from the attack position to the kill zone, a combination of time to target/time on target (TTT/TOT) and visual signals should be used. FMFM 3-1 lists the control measures currently used by ground forces to achieve coordination and control. The TOW attack, whether short of the FSCL or beyond, can also be controlled by adopting these same control measures. By establishing phaselines, checkpoints, contact points, rendezvous points, release points, axes of advance, and other controlling measures in conjunction with a timing sequence for each, final coordination can be assured. Visual signals used with a time sequence may also be used to coordinate actions and provide some degree of flexibility for the TOW team leader. (See Chapter 7 for addtional information.)

11.6.8 Supporting Arms. The effective use of supporting arms can do a great deal to achieve success and enhance survivability. The procedures for the control of supporting arms are covered elsewhere in this manual. Ideally, supporting arms may be used to destroy enemy targets during the attack, but suppression alone may be sufficient to ensure the success of the attack. Supporting arms may also be used as signaling agencies and assist in the control of the overall effort. Even during daylight hours, an artillery flare over the kill zone can be an excellent signaling device to commence the attack. It is recommended that whenever possible the actual control of a specific supporting arm be delegated to an aircraft within the covering element. Full integration of all the supporting arms used in the attack can be achieved by designating sectors of fire to each controlling aircraft, based on their position relative to the kill zone. When using high-performance attack aircraft and artillery, it is advisable to assign those sectors to the attack aircraft that are opposite the gun target line. The recommended priority is to initiate the attack with artillery or naval gunfire in a flak suppression role. Hopefully, this will result in the destruction of their exposed radar systems and force them into an optical tracking mode which is to be obscured by the covering elements. The targeting priority for artillery and naval gunfire should be the ADA. Immediately following would be the combined high-performance attack aircraft and AH-1T engagement concurrent with the ongoing artillery. From the beginning, AH-1s acting as the covering element would provide marking and suppressive fires while creating a deception. As you might imagine, an attack of this magnitude must be well planned and executed. Figure 11-7 depicts a kill zone with sectors assigned to various supporting arms.

11.6.8.1 High-Performance Aircraft. High-performance aircraft are vulnerable to many of the ADA systems that plague the attack helicopter. It is therefore essential that their use capitalize on their speed, surprise, and fire power. The pop-up attack will most likely be the method of delivery. Multiple runs should be discouraged. The combined attack by both attack helicopters and attack aircraft should saturate enemy radars and force enemy gunners into a split scan which will degrade their effectiveness. It might be more desirable to allow the high-performance aircraft to engage tanks with Rockeye while using the TOW missile against ADA vehicles. Time-on-target techniques, combined with identifiable sectors of fire, should assist in control. Target marking may be ineffective because of the amount of smoke that may be expected in the kill zone. In all cases, obscurants should not be used near targets that are to be engaged with the TMS. Command and control responsibilities in the kill zone should be assigned to the FAC/FAC(A) by either the DASC or the ground element. When the attack is conducted near friendly forces, the TACP should be used as much as possible.

11.6.8.2 Artillery/Naval Gunfire. These two supporting arms offer perhaps the greatest advantage against enemy mechanized forces. While they are not accurate enough to engage armor, they can be effectively employed against all known ADA using variable time fuze settings. Barrages may also be used to channelize armor columns into more favorable terrain and to obscure mutually supporting armor columns, enabling engagement of one without interference from the other and covering the egress of the TOW team after the attack has been terminated. Artillery/NGF lends itself also to time-on-target control, and each may be controlled separately by elements of the covering element. Again, planned sectors of fire should preclude interference with other support arms. Operations within the FSCL and NFL can be controlled and coordinated by TACP and FO teams, assuming they can observe the kill zone. Careful consideration should be given to the types of fires to be requested, with every effort made to avoid obscuring the kill zone with either high explosive or smoke rounds. Night illumination by artillery and naval gunfire also enhances planned night attacks. In either case, the request, planning, coordination, and control of artillery and naval gunfire should be emphasized for every attack.

11.6.8.3 Attack Helicopters. AH-1s without the TMS are largely concentrated within the covering element. Do not disregard attack helicopters as an effective suppression, if not a destructive element. As an attack commences, the attack helicopter can be used to obscure close-range targets and to engage, if necessary. The attack helicopter capability is the filler and also requires the planning and coordination demanded by other supporting arms.

11.6.9 Kill Zone. The kill zone should be selected primarily from a defensive perspective. While it is desirable to destroy the entire armor force at one time, the tradeoff must be examined in light of defensive considerations. Several kill zones designed to destroy only a few of the enemy along his axis of advance may be preferable. This is especially true when the terrain does not favor a more aggressive approach. The purpose of these smaller kill zones is to slow the enemy's momentum while steadily destroying a few vehicles at a time. From the holding area to the attack position, less emphasis will be placed on stealth in favor of a rapid transit. It may become necessary to decrease the number of AH-1 helicopters, as large flights are more difficult to control in a rapidly moving situation. Deception plans should be formed to deceive the enemy as to the intended direction of attack. Care should be taken so that exposed aircraft are well out of the range of the ADA system accompanying the armor force.

11.6.10 Firing Points. The necessity for rapid reaction may preclude visual reconnaissance and

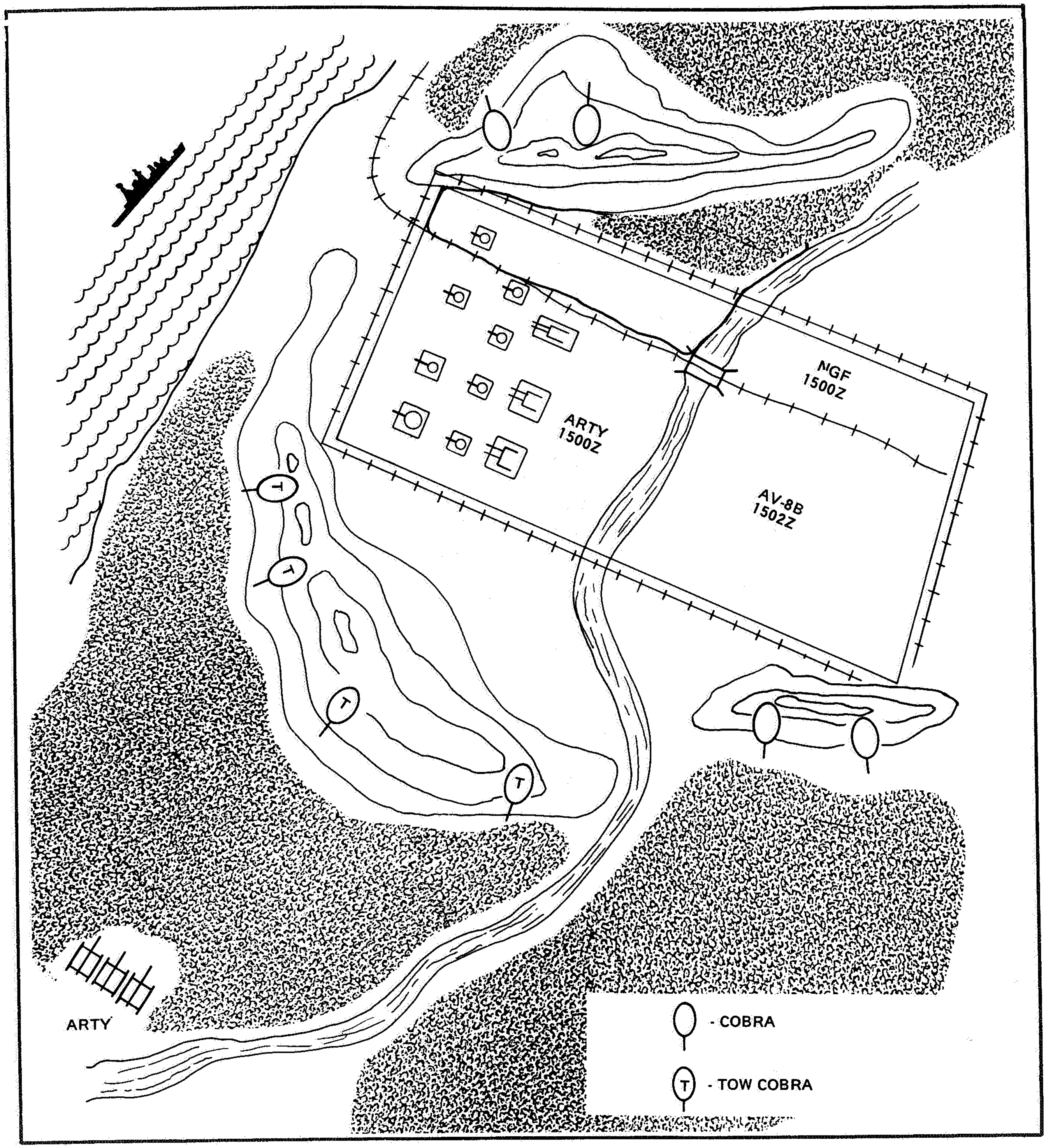


Figure 11-7. Kill Zone With Sectors Assigned to Various Supporting Arms

the selection of firing points for the flight. A thorough map and aerial photo study may be all that time allows. Because of this, precise firing points may be altered to a limited degree by each aircraft in order to ensure requisite survivability. A greater reliance on radio communication, as undesirable as it may be, may drive true line-of-sight firing points. Actions at the firing point must be thoroughly standardized. The tactical SOP is designed to accomplish precisely that and should be implemented throughout the parent command. Finally, alternate firing points may not be available, and often procedures will have to be developed either to vacate a firing point or to abort the mission.

11.6.11 Covering Point. As the desired rapid reaction reduces the desired detailed planning, it becomes essential that the covering element provide especially alert security. The surprise introduction of an enemy force without being challenged on the flank or rear of an engaged flight will have disastrous results. Since an adequate route reconnaissance has not been conducted, overwatch techniques should be employed from the crossing of the FEBA to the firing point. Additionally, a greater reliance on AH-1s for fire support requires that each aircraft be in a position to deliver accurate and rapid fire into the kill zone, as well as provide for security and the other tasks that may be their assignment. If feasible, the covering point should be located away from the firing point if deception plans are to be exercised.

11.6.12 Ingress/Egress Routes. Route selection must be geared to providing maximum cover and concealment while expediting movement to the firing points. To avoid confusion, the routes should be easier to navigate and relatively direct. Flight dispersion must be maintained and allow sufficient response room for the covering element. Avoid navigating the entire team into an area where little or no intelligence data has been obtained.

11.6.13 Attack Positions. Depending on whether final coordination has been achieved prior to departing the holding area, the attack position may be eliminated altogether. It may be used to buy time for the final attack and to reorganize if the situation dictates. The decision as to whether to continue the mission should be made at this point.

11.6.14 Holding Area. Unless the flight is familiar with the current tactical situation, every effort should be made to receive an intelligence update and friendly forces brief, and to establish final coordination at the holding area. After departing the holding area, all changes to the tactical situation will have to be transmitted via radio, as shuttle aircraft and vehicles cannot hope to overtake the flight as it moves forward.

If time allows, refueling and rearming should be accomplished, allowing the flight leader more in-flight flexibiity. Should the flight become scattered or disoriented, the rendezvous should occur at the holding area. The fast changing enemy situation may deteriorate quickly, and the flight may be virtually unaware of this fact.

11.7 ORGANIZATION — ANTIARMOR ROLE

In the antiarmor role, the basic organizational unit for the employment of the AH-1T is the division. Each flight should be structured to contain an attacking section of TMS-equipped AH-1Ts and a covering section of AH-1s. The flight leader should be in the cover section. This will free the flight leader to control the engagement without degrading the TOW capability. He is assisted in the control of the division by a section leader in the TOW aircraft, and if necessary, a covering section leader. The latter will be determined by the number of aircraft in the covering element. This organization lends itself to reinforcement for larger engagements, yet allows a basic element to maintain a similar capability on a smaller scale. The flight leader is the mission commander and is responsible for the planning and execution of the mission. He should be a highly qualified attack helicopter commander with TOW experience, a designated FAC(A) or TAC(A) and a formation leader appropriate for the number of aircraft in the flight.

11.7.1 Attack Flight. The attack flight should be comprised of a minimum of two AH-1T aircraft. The total size of the attack flight is determined after an analysis of the METT considerations and should be tailored as appropriate. The minimum composition merely allows for platform redundancy if a system failure or aircraft loss should occur prior to target destruction and mutual support if the attacking element is separated from the covering force. With extremely large attacks, the total number of AH-1Ts may be larger, dictating more than one attack flight. The responsibility of the attack flight is to destroy the primary target as determined by the flight leader. It should be understood that this is the sole cause for its existence, and acceptance of any mission that degrades this capability should be avoided. Independent operation of the attacking flight without the attendant covering flight should be accomplished only after careful consideration. While it is understood that the AH-1T has a self-defense capability, the total inventory of TOW aircraft available dictates a more cautious use.

11.7.2 Covering Flight. The covering flight is comprised of two or more AH-1s and is tasked with a variety of missions designed to enable the attacking flight to engage the primary targets relatively undistracted. The flight leader should be located within the covering flight or in large-scale attacks and operate in a section separate of both the attack and covering flight. The responsibilities of the covering flight begin at the point of origin with the planning of the mission. Specific actions to be accomplished by each aircraft should be identified early to allow for their proper preparation. Appropriate roles for the covering flight are not limited to, but include, the following:

1. Reconnaissance forward of the holding area for both contingency and assigned missions

2. Establishing initial contact with the enemy and maintaining that contact as deemed appropriate by the flight leader

3. Providing security from ground and air threats for the attack flight en route, during holding and at the kill zone

4. Providing suppressive fires at the kill zone in support of the attacking flight

5. Controlling supporting arms as defined by the flight leader both en route and at the kill zone

6. Assisting the flight leader in the control of the attack by signaling or radio relay

7. Executing a deception plan designed to divert ADA attention in support of an attack

8. Destroying point targets in support of the attacking flight.

11.7.3 En Route Formations. TOW flight formations are established to allow the TOW flight to travel en route expeditiously with the maximum protection. The principles of helicopter escort apply with only the transport aircraft being replaced by the TOW aircraft. As the proximity of the threat drives the TOW flight to a greater dependence on masking, terrain and vegetation become obstacles that make rigid formations difficult if not impractical. At altitudes where little or no vertical obstructions exist, combat spread forms the basis for the escort formation. The primary concern of early warning is enhanced consistent with the advantages of mutual support, section integrity, and 360° flight observation. Cruise principles are used to capitalize on radius of turn effect with exception of the evasive break. Should the flight have to break down its lateral orientation in favor of an orientation of depth for the NOE profile, the covering flight should reposition behind the attack flight. This enables the 6 o'clock of the flight to be cleared from an air threat by the cover flight prior to committing the TOW flight to the more vulnerable NOE profile. It is necessary to provide rear protection at slower airspeeds and lower altitudes without unnecessarily endangering a TOW aircraft. Throughout the flight, adjustments will be made from the more desirable lateral orientation and that evolution may be reversed. Sufficient flexibility exists to allow for that procedure. Traveling, traveling overwatch, and bounding overwatch are discussed in Chapter 6. Figures 11-8 through 11-11 depict the en route formations recommended. Should the total number of aircraft exceed six, the TOW flight should be broken into smaller flights for the operation. Aircraft distances must be determined after consideration of threat, visibility, engagement ranges, and terrain. Evasive breaks are likewise similar to those techniques used in the escort of transports in the combat spread formation. The most forward aircraft disengages and evades while subsequent aircraft use their longer slant ranges for suppressive forward-firing ordnance delivery prior to their disengagement and evasion. Conventional ordnance on the inboard stations of the TOW aircraft are ideal for this. When flying in and among terrain and vegetation, single aircraft provide a fire suppression capability similar to that of sections, although of a lesser volume. All aircraft must maintain visual contact with that aircraft immediately forward. Should the first aircraft have to evade enemy fire or observation, his primary concern will be to place terrain or vegetation between himself and the enemy while using the turret as much as possible for fire suppression. The subsequent aircraft will deliver fire from either turret or wing stores if possible, on the target as marked by the first aircraft's 20 mm. Since radio calls may not be feasible or desirable, alternative methods of initiating the evasive break should be identified, briefed, and rehearsed.

11.8 FIRE COMMAND AND CONTROL

11.8.1 Tactical Communication. Radio communication between aircraft must be limited to that necessary for mission accomplishment. The terrain flight environment may preclude the use of radios and the possibility of jamming will always exist. The requirement to communicate may be kept to a minimum through standardized procedures, detailed planning, and briefing.

11.8.2 Target Designation and Distribution. Target designation may be accomplished in a variety of ways, each designed to achieve full flexibility and speed and to realize the maximum number of kills. The following methods of target designation are designed to provide clear and concise orders that are essential for the proper distribution of fire.

11.8.2.1 Designation of Sectors (All See Same Target). In this situation, the kill zone is subdivided into smaller kill zones. This may also be necessary when a particularly large force is to be engaged in order to concentrate fires. Linear features are best designed for this purpose as roads, streams, and hedgerows allow for immediate orientation. By using magnetic directions based upon these ground features, the kill zone subdivision may be accomplished expeditiously. It is imperative that the reference feature used be clearly apparent to all members of the attack element. Such a division might be briefed as "OZONE FLIGHT, EAST OF THE POWER LINES; VADER WEST."

11.8.2.2 Designation of Sectors (All Do Not See Same Target). The possibility that all members of the TOW team may not see the same target or kill zone is not remote. As a matter of fact, it may be more common. In these cases, the very terrain that obstructs observation should be used to define the sectors of employment. "HUSTLER FLIGHT, NORTH OF TREE LINE; TORCH SOUTH."

11.8.2.3 Distribution of Attack Flight Fires. In order to place maximum effective fire on the

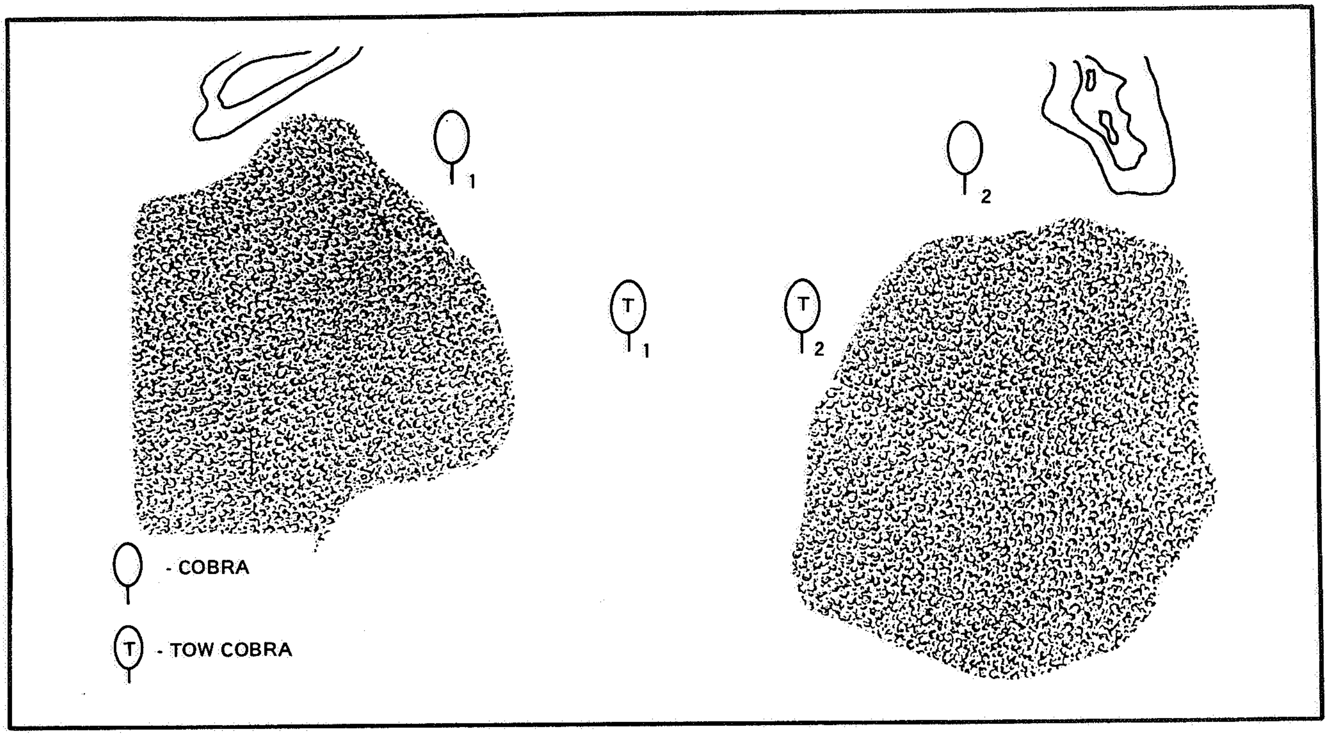


Figure 11-8. Four Aircraft TOW Team Formation — Lateral Orientation

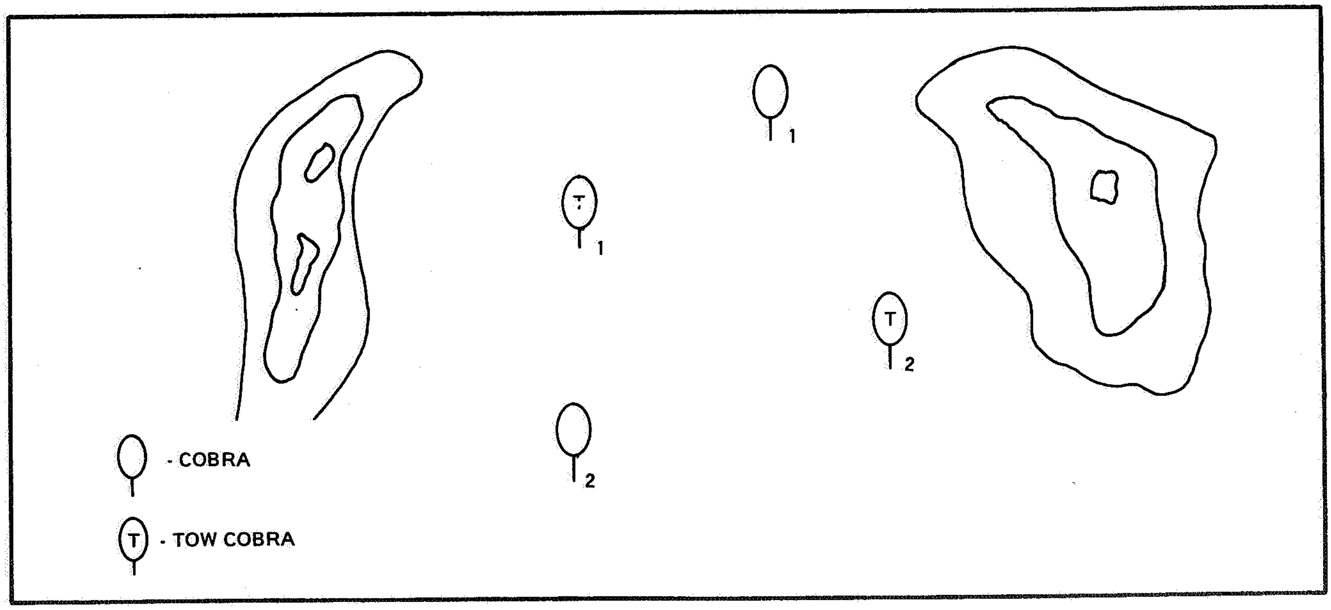


Figure 11-9 Four Aircraft TOW Team Formation — Deep Orientation

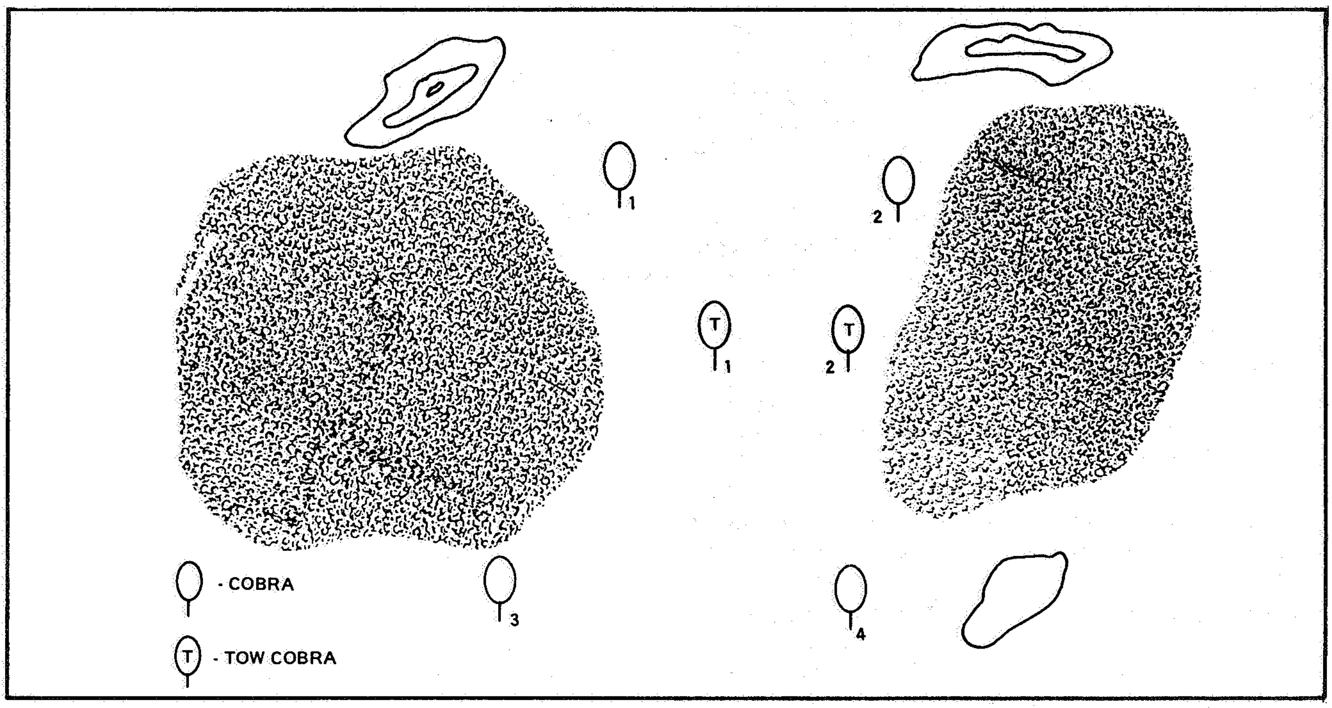


Figure 11-10. Six Aircraft TOW Team Formation — Lateral Orientation

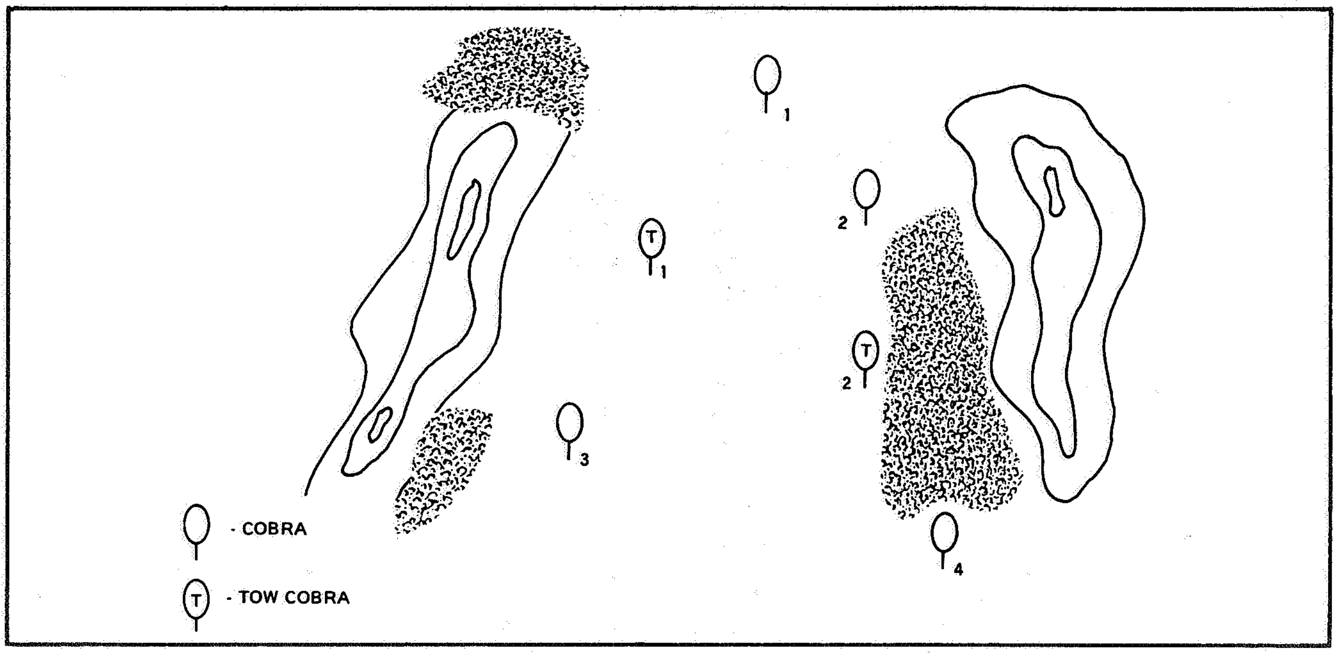


Figure 11-11. Six Aircraft TOW Team Formation — Deep Orientation

target and still exercise proper control, targets should be engaged in the following manner whenever possible. The target array should be engaged from its extremities or fringes toward the center. To accomplish this, the following procedures are recommended:

1. Left aircraft shoots left and leading vehicle.

2. Right aircraft shoots right and rear vehicle.

3. Center aircraft shoots center and command vehicle.

Suppressive fires should be called upon the target at the earliest possible moment to coincide with the TOW attack and continue throughout the engagement, until the TOW aircraft have remasked. Suppressive fires may be withheld in unusual situations; for example, the need to achieve surprise or prevent target formation change. In all cases, airburst fuzes should be employed to prevent target obscuration.

11.9 EMERGENCY PROCEDURES — TOW MISSILE

11.9.1 Definitions

1. Misfire — occurs when an attempt to fire is made and launch motor ignition does not occur. This would be indicated by a FIRE flag in the TSU.

2. Hangfire — launch motor ignition has occured, but the missile has not separated.

11.9.2 Misfire Procedures

In the event of a misfire:

1. TCP mode select switch — OFF.

2. MASTER ARM — STBY or OFF.

3. Return to base via a hung ordnance pattern.

4. All personnel must remain clear of the aircraft. The crew should remain in the aircraft for a 30-minute, cool-down period after the TCP is turned off.

5. The missile should be removed and disposed of by an EOD team.

If the mission must continue, maintain the aircraft in the safest direction and proceed as necessary.

Return to ship with a misfire missile:

1. Set appropriate RADHAZ condition aboard ship.

2. Remain clear of the ship until 30-minute, cool down has been accomplished.

3. Approach and land via the appropriate hung ordnance pattern.

4. Remove and dispose of the missile after dearming.

11.9.3 Hangfire Procedures. In the event of a hangfire, jettison the launchers immediately and clear the area.

11.10 NIGHT OPERATIONS

(For additional information, see Chapter 10.)

In order to employ the TOW missile at night, artificial illumination will be required, in all but the most ideal of conditions. Even with the use of night vision goggles, acquisition and tracking of a target are extremely difficult without artificial illumination.

The TSU allows only 30-percent visible light through the optics. This reduction makes the acquisition of targets during night conditions extremely difficult at ranges in excess of 800 to 1000 meters. In order to identify a tank silhouette at 1500 to 2000 meters, while looking through the TSU, a light intensity of at least 0.66-foot candles is required (0.66-foot candles is equal to 30 times the ambient light level of a full moon). The minimum illumination required is 3,300,000 candlepower. The initial acquisition may take up to 45 seconds and additional flares should illuminate slightly to the rear of a suspected target. This should backlight the target and aid in acquisition because of the silhouette. Once the target is acquired, the subsequent flares should be placed slightly in front of the target to aid in tracking. Any lapse in illumination during tracking will probably result in a loss of the target through the TSU and a subsequent miss.

PART III

Air-to-Air Warfare

Chapter 12 — Air-to-Air Warfare

CHAPTER 12

Air-to-Air Warfare

12.1 INTRODUCTION

The scope of this chapter is to address airborne weapons platforms that pose a threat to helicopter aviation. It is not the intent to list each threat system, but to describe those maneuvers and tactics which have proven successful in rendering those systems ineffective.

The tactical maneuvers described in this chapter have been tested and verified. Most studies indicate that the helicopter can survive engagements with airborne weapons systems, if these maneuvers are executed properly, and the pilot remains unpredictable.

12.2 STANDARD TERMINOLOGY

All aircrewmen must be aware of the possible confusion associated with flight in an intense, maneuvering combat environment. Standardized terminology, familiar to all individuals concerned, will help minimize confusion. The following terms are provided for standardization.

12.2.1 General Terms

1. Head on — the adversary aircraft is directly ahead, flying toward the engaged helicopter. Use of this term implies only a head-on situation and does not indicate relative speed or distance.

2. Tail on or astern — indicates a position directly behind the adversary's aircraft. Use of this term implies no reference to altitude, closure rate, or distance.

3. Port or starboard turn — indicates direction of *turn* (e.g., "TAC PORT GO").

4. Direction and clock code — used to indicate the angular position of objects with respect to the nose of the aircraft or the axis of advance of the flight. A direction right or left, is used to provide an instant cue of which direction *to look* while the clock narrows down the visual sector. (e.g., "BOGEY RIGHT, 3 O'CLOCK HIGH").

5. Altitude — indicates vertical position relative to the pilot's perceived horizontal reference plane. In general, these terms are used in conjunction with the clock code.

   (a) Level — the plane of reference which appears to be at the same altitude or level with the observer.

   (b) High — above the observer's horizontal *level* reference plane.

   (c) Low — below the observer's horizontal *level* reference plane.

6. Rolling in — refers to the maneuver of an aircraft as it turns to commence an attack.

7. Bogey — an aircraft that has been sighted but not identified.

8. Bandit — a recognized enemy aircraft.

12.2.2 Terminology Between Members of a Flight

1. TALLY — refers to visual contact with the adversary.

2. VISUAL — refers to visual contact with one's own flight or wingman (e.g., "VISUAL" or "NO VISUAL").

3. PADLOCK — a call that indicates one aircraft or a crewmember in the aircraft has dedicated himself to visually following the adversary.

4. BREAK — a maximum performance emergency maneuver executed by the flight for the purpose of initially orienting the flight during an attack. Two radio calls are required: (1) "FLIGHT BREAK (DIRECTION) . . . NOW" and (2) "FLIGHT ROLL OUT ON (HEADING) OR (NOW)."

5. FREE — the helicopter that is not directly engaged by the adversary aircraft in a two versus two or two versus many engagement. (The free aircraft must always maneuver to support the engaged aircraft visually and/or with weapons.)

6. ENGAGED — the helicopter that is engaged by the adversary aircraft. The engaged aircraft is always the tactical flight leader. (Free and engaged roles can switch many times during an engagement, and each change constitutes a change of the tactical flight lead.)

7. WINCHESTER — all ammunition expended.

12.2.3 Intercockpit Terminology

1. TURNS — when a turn is called, a 30° to 45° angle of bank is understood. The words HARD PORT/STARBOARD indicate that a 60° angle of bank is desired. The words STOP TURN should be used to indicate return to level flight (e.g., "PORT TURN!" or "STARBOARD TURN!"; "HARD PORT" or "HARD STARBOARD "; "STOP TURN!")

2. REVERSE — refers to turns only, and indicates reversing both direction and severity in kind. A reverse call initiated while in a left hard turn results in a right hard turn.

3. SPLIT — refers to a 180° turn away from the rest of the flight.

4. PITCH— a call to "PITCH UP" or "PITCH DOWN" indicates a pitch "angle of 15°. "PITCH HIGH" or "PITCH LOW" means a 25° to 30° pitch angle is desired. For pitch angles less than 15°, use the words, CLIMB or DIVE, with the words HIGHER or STEEPER being used to adjust.

12.3 SINGLE AIRCRAFT TACTICS

The tactical maneuvers described herein have been tested and verified. Most studies indicate that the helicopter can survive engagements with airborne weapons systems if these maneuvers are executed properly and if the pilot remains unpredictable.

12.3.1 Single Aircraft Tactics Against Fixed Wing

12.3.1.1 Prior to Acquisition. If the enemy aircraft has not visually acquired the helicopter, then the following three steps may assist the helicopter in remaining undetected:

1. Avoid contrast — avoid terrain that provides visual contrast with the helicopter. Proper camouflage paint to match the terrain helps considerably. Use cloud and terrain shadows to prevent reflections from canopies and rotor blades.

2. Fly at a lower altitude — flight as low as possible and terrain masking aid in camouflage and in reducing the size of the helicopter's shadow.

3. Limit motion — avoid hard turns that cause glint. Use slower airspeeds to reduce relative motion.

12.3.1.2 Defending Against Attack. Once the helicopter has been visually acquired, the attacking aircraft will usually start a turn directly toward the helicopter. Once it is confirmed that the enemy aircraft has visual contact and attack is imminent, the helicopter should take the following steps:

1. Make an immediate turn toward the attacking aircraft before it comes into range. Acquire maximum airspeed and climb to a maneuvering altitude that will allow adequate terrain clearance for jinking maneuvers. This reduces the attacker's time to track the helicopter by significantly increasing the closure rate. For example, if the attacking aircraft is moving at 400 KIAS and the helicopter is flying at 130 KIAS, the closure rate is approximately 895 feet per second during a head-on attack and 456 feet per second during a stern attack. These closure rates result in effective firing times, *within* 4,000-feet range and with a break off at 1,000-feet range, of 3 seconds and 7 seconds respectively.

2. When the attacking aircraft rolls to track the turn and then stops his roll, turn immediately in the opposite direction. Descend in a side-slip; if possible, do not allow the attacker to *pull lead.*

3. When the attacking aircraft begins to pull off, immediately make a hard turn in the shortest direction to follow the attacker. If already established in a jinking turn, simply hold the turn. Head for the attacker at maximum airspeed and attempt to remain in his blind spot. This is the tail-chase maneuver. It ensures that the helicopter pilot maintains direct visual contact with the attacker and shortens the lateral distance between the attacking aircraft and the helicopter. It will force the attacker into a steeper attack angle should he attempt an immediate reattack (see Figure 12-1).

4. During an attack, avoid turning more than 45°. Turning broadside to the attacking aircraft provides a larger target and makes the helicopter's maneuvers predictable.

5. Stay unpredictable. Enemy fighter pilots expect helicopters to follow the natural contours of the terrain. A helicopter can spoil an attack and often break visual contact by altering the flightpath in a valley and jumping a ridge into an adjacent valley. A predictable maneuver, such as a 180° turning reversal, will aid the attacker in leading the helicopter and timing his gun pass to coincide with the projected flightpath. Once visual contact is lost, reacquisition depends on the attacker's fuel supply and friendly air defenses.

WARNING

Attacking aircraft normally operate in section. Beware of follow-on attacks from enemy wingmen as you turn toward the first aircraft's tail. Keep all enemy aircraft in sight. Jinking maneuvers, vice tail-chase maneuvers, are probably the better course of action if there is more than one attacking aircraft.

12.3.1.3 Second Pass Situation. The common tendency of the unprepared fighter pilot upon overshooting a target is to use a vertically oriented, high-g 180° reversal to reattack as quickly as possible. The tactic is effective against a stationary target, but against a 130-knot helicopter that is chasing the attacker throughout the reversal, the result will be that the helicopter is at a very close range, if not directly below the attacker by the time the reversal is completed. Continue the tail-chase maneuver until the attacking aircraft is forced to extend his position in order to attempt another attack. The attacker may lose sight of the target temporarily during his extension. This is the ideal time to seek terrain for concealment. Keep in mind that the helicopter

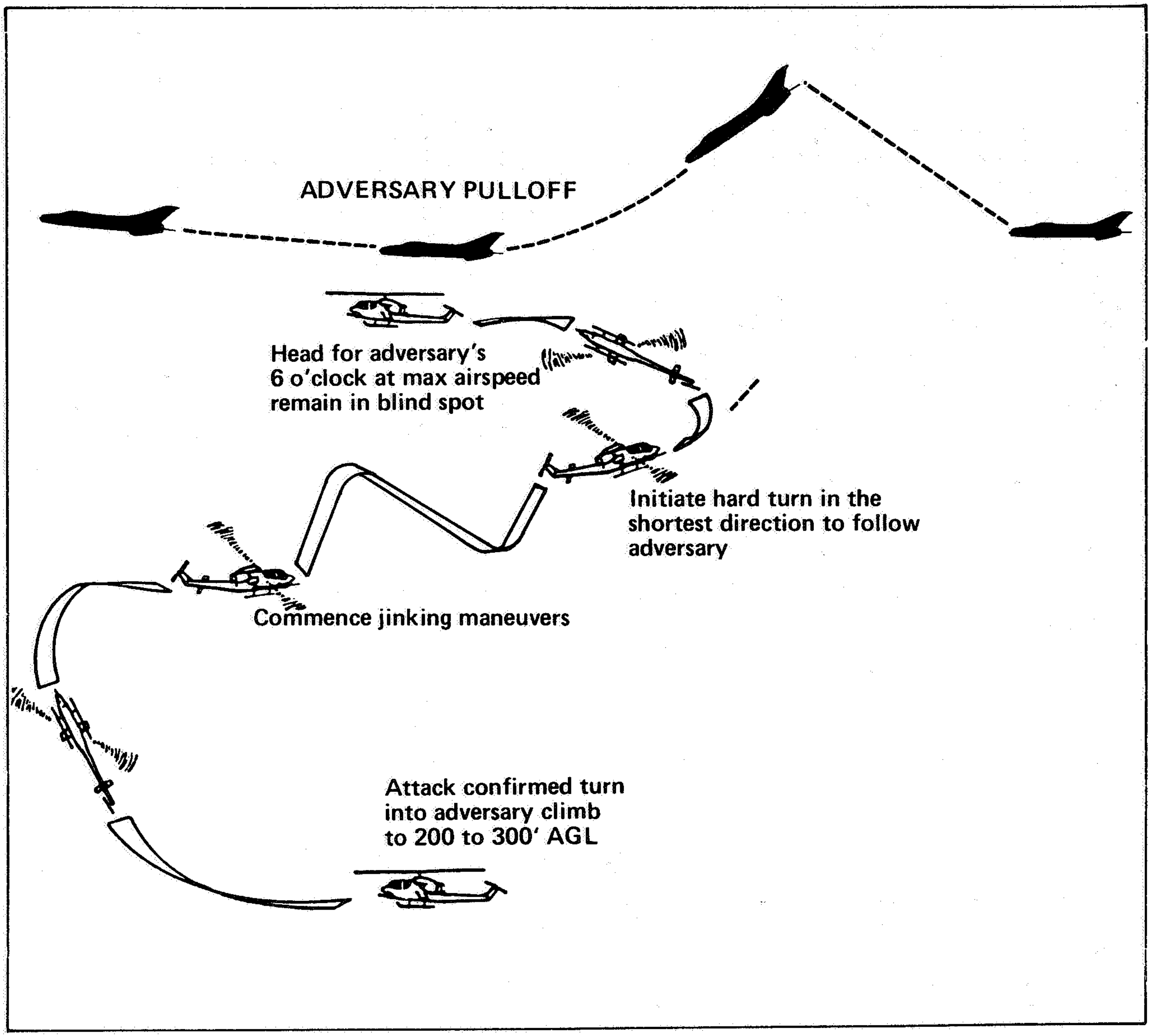

ADVERSARY PULLOFF
Head for adversary's 6 o'clock at max airspeed remain in blind spot
Initiate hard turn in the shortest direction to follow adversary
Commence jinking maneuvers
Attack confirmed turn into adversary climb to 200 to 300' AGL

Figure 12-1. Tail-Chase Maneuver

should attempt to displace from the area where the last encounter took place, since that is where the attacker will look to reacquire the helicopter.

If the attacker attempts to turn in the horizontal, cut the circle behind him. This forces the attacker into an arc and provides a shorter path to his rear hemisphere. It is similar to a carrier type rendezvous.

If the attacker extends, attempt to remain at his 6 o'clock so that he loses sight. Then displace and attempt to find terrain that will provide masking or cover. Remember to ensure that at least one crewmember maintains a *padlock*.

Try to anticipate the attacker's next maneuver because it will assist in deciding whether or not to remain concealed, run, or turn into the attacker again.

12.3.1.4 High-Altitude Flight. Because of its vulnerability to both air-to-air and ground-to-air threats, it is not feasible for the helicopter to fly at a high altitude in contested airspace. If caught at high altitude, the helicopter pilot should attempt to keep the attacker in sight at all times, maintain maximum rate of descent, and use as much side slip as is comfortable. When the attacker comes within firing range, use jinking to destroy the attacker's tracking solution.

12.3.1.5 Sequential Attacks. A helicopter's chances of surviving a sequential attack by two attackers is substantially less than in a one versus one situation. The tactics remain essentially the same as with a single attacker. Instead of executing the tail-chase maneuver with the first attacker, the helicopter should turn into the second attacker, keeping all enemy aircraft within sight.

12.3.2 Tactics Against Armed Helicopters. The accelerated development and employment of armed helicopters within Warsaw Pact and Third World armed forces practically assures confrontation with armed helicopters on any modern battlefield. Most Soviet helicopters have a weapons delivery capability and performance and flight characteristics equal to or better than their U.S. or NATO equivalents. The HIND, in particular, is capable of employing guns, rockets, ATGMs, air-to-air missiles, and bombs. Tactics used against this threat vary from those used against fixed-wing threats. The primary tactics against the armed helicopter are as follows:

1. Avoid the threat by careful planning and terrain masking.

2. If seen by an armed helicopter, attempt to break contact. Employ terrain masking, call for help, and if required, employ appropriate air-to-air maneuvers.

12.3.2.1 Introductory Maneuvers. The following introductory maneuvers are provided to gain an offensive position or to counter an aggressor's initial move. The objective is to foil initial effective weapons employment by the enemy and establish a position in the rear hemisphere that allows offensive weapons employment and/or prevents the enemy from bringing his weapons to bear.

12.3.2.1.1 High Yo-Yo (In Gun Range Maneuver (Figure 12-2). The high yo-yo is a maneuver in which a helicopter maneuvers through the vertical and horizontal planes to prevent an overshoot in the plane of the enemy's turn. An overshoot can be generated by too much angle off, excessive overtake, or a combination of both. When the nose begins to slide behind the enemy, the aircraft is no longer in the enemy's turning radius and must break off to prevent overshoot. To accomplish the maneuver:

1. Roll wings level and zoom in the vertical plane to the rear of the enemy trading airspeed for altitude to prevent overshooting your opponent. Nose-to-tail separation can be adjusted at this point.

2. Roll toward the enemy's 6 o'clock position and close to weapons parameters.

Note

Because of dissipation of airspeed at the apex of the climb, lag pursuit or a low yo-yo may be required.

12.3.2.1.2 Defense Against a High Yo-Yo. If the enemy executes the high yo-yo properly, the helicopter has little opportunity to dive away, due to slow opening speeds and lethal ranges of weapons employed by the enemy. The helicopter can use two basic countering maneuvers depending on nose-tail separation from enemy.

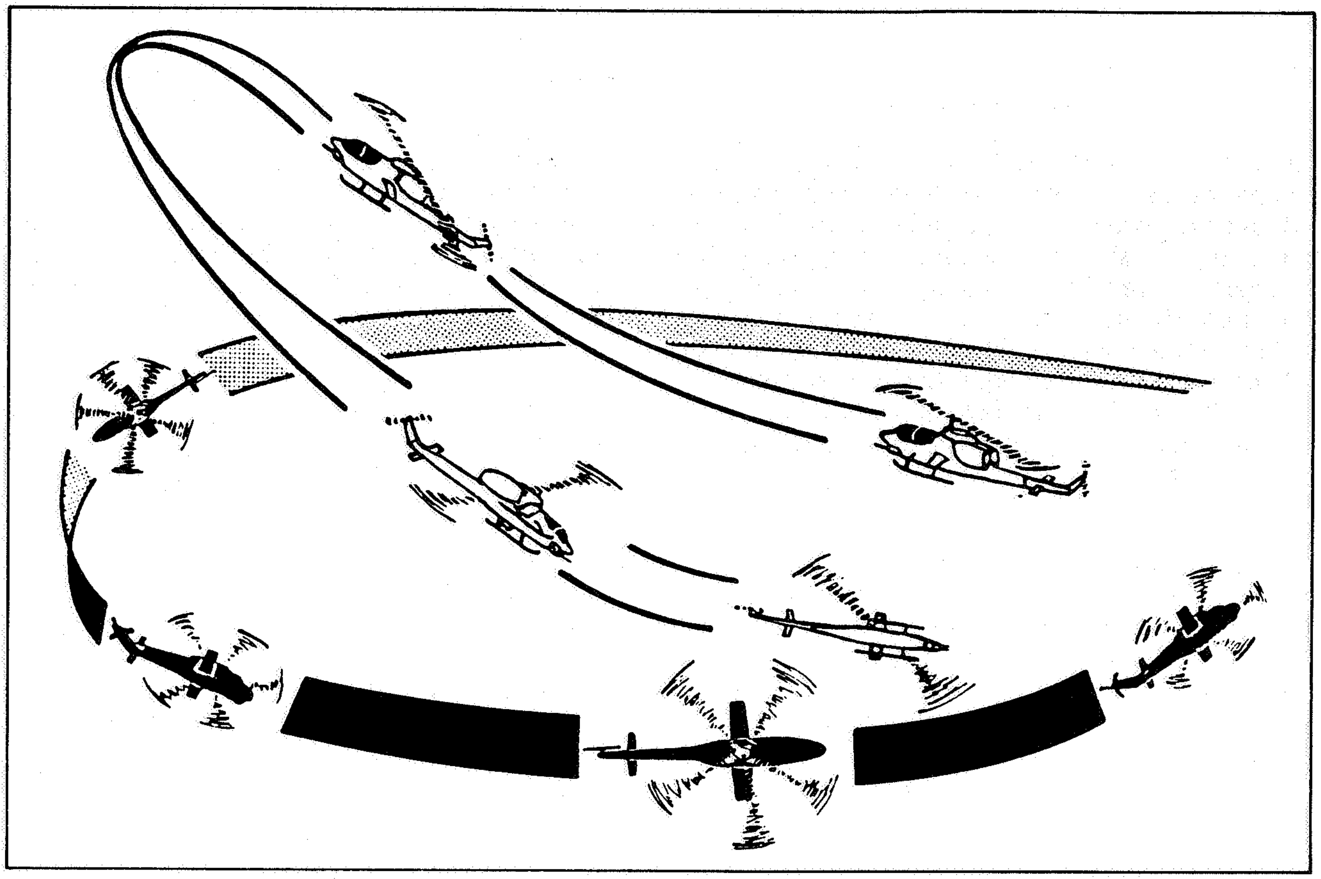


Figure 12-2. High Yo-Yo

If a high yo-yo attack is executed with short nose-tail separation (500 feet or less), the helicopter should initiate a break into the enemy to cause an overshoot. Before turning so far as to lose sight, roll wings level and, airspeed permitting, initiate a wing-over maneuver to force the enemy low. Maintain altitude and airspeed. If airspeed does not permit a wing-over maneuver, break into the enemy after the overshoot.

CAUTION

Avoid breaking into a horizontal scissors.

With long nose-tail separation (greater than 500 feet) against a high yo-yo, the helicopter should initiate a defensive pull-up after a nose-low commitment is made by the adversary. The defensive pull-up is a rolling climb initiated to cause an overshoot and gain nose-tail separation while holding advantage over the enemy (Figure 12-3).

12.3.2.1.3 Wing-Over Maneuver. In a situation in which a friendly helicopter approaches an enemy armed helicopter at high angle-off and long range, the wing-over maneuver should be used. The wing-over maneuver is designed to give an altitude advantage while using rotor disc masking of the enemy's weapons. The maneuver should be entered with high airspeed. Just prior to entering effective enemy weapons parameters (1,500 to 2,000 meters), initiate a *pop-up* maneuver (25° to 35° nose up) to seize the advantage and exit enemy weapons parameters. Upon reaching the desired altitude, roll toward the enemy and maintain sight. Maintain positive g-loading, and allow the nose to fall below the horizon. If armed and a slashing attack is desired, dive for a point approximately one-half the distance between your position and the enemy's position over the ground. Otherwise, as the nose falls below the horizon, turn 180° into the enemy and maneuver to the optimum tail-chase position (Figure 12-4).

Note

> This is a wing-over type maneuver which is intended to gain altitude advantage over the opponent.

12.3.2.1.4 Defense Against a Wing-Over Attack. The defense against a wing-over attack is predicated upon the point of intercept and aircraft separation. A nose-high turning climb into the enemy should be executed after the nose-low commitment is made by the enemy. Depending on the enemy's position, as much as 360° of turn may be required to maintain sight, attain an overshoot, and acquire the desired nose-to-tail separation (Figure 12-5).

12.3.2.1.5 Horizontal Scissors. The horizontal scissors is a defensive maneuver which normally should be avoided. The horizontal scissors can be used if airspeed and nose-tail separation do not permit another maneuver. When in this position, increase rate of turn into the attacker until he overshoots or moves outside your radius. As the attacker passes, execute a horizontal reversal. The decision on when to reverse your turn will depend on how rapidly the attacker slides to the outside of the turn and how far he slides through your flight-path. A good rule of thumb is rapid overshoot, early reversal; slow overshoot, late reversal. Reversing the turn too early can be to the attacker's advantage. Repeat the hard-turn reversal each time the opponent crosses your flightpath to the outside of your turn.

Attempt to turn in phase with your opponent if you find yourself below and behind him. This places the opponent at a visual disadvantage with the subsequent possibility he may maneuver incorrectly, allowing you to acquire a firing (or tail-chase) position.

Because of the characteristics of helicopters and the capabilities of turreted weapons, the aircraft that loses airspeed/energy first will be at the mercy of the aircraft that can maneuver effectively while maintaining airspeed (Figure 12-6).

12.3.2.1.6 Defense Against a Horizontal Scissors. To avoid engaging in the horizontal scissors with an attacker, employ the following technique:

When overshooting your opponent's turn radius, do not attempt to pull even harder inside his turn or reduce power. Instead, relax the turn to help maintain maneuvering airspeed. When passing your opponent's 6 o'clock position, roll wings level and pull up. When the adversary sees you rapidly going to the outside of his turn, he will be tempted to reverse toward your aircraft. If the adversary does reverse toward you, hold his 6 o'clock position. If the defender does not reverse, continue as for a high yo-yo.

12.3.2.1.7 Low Yo-Yo. The low yo-yo is an effective maneuver that is used to decrease range or increase rate of closure. To begin this maneuver, lower the nose and turn to the inside of the enemy's defensive turn. The range

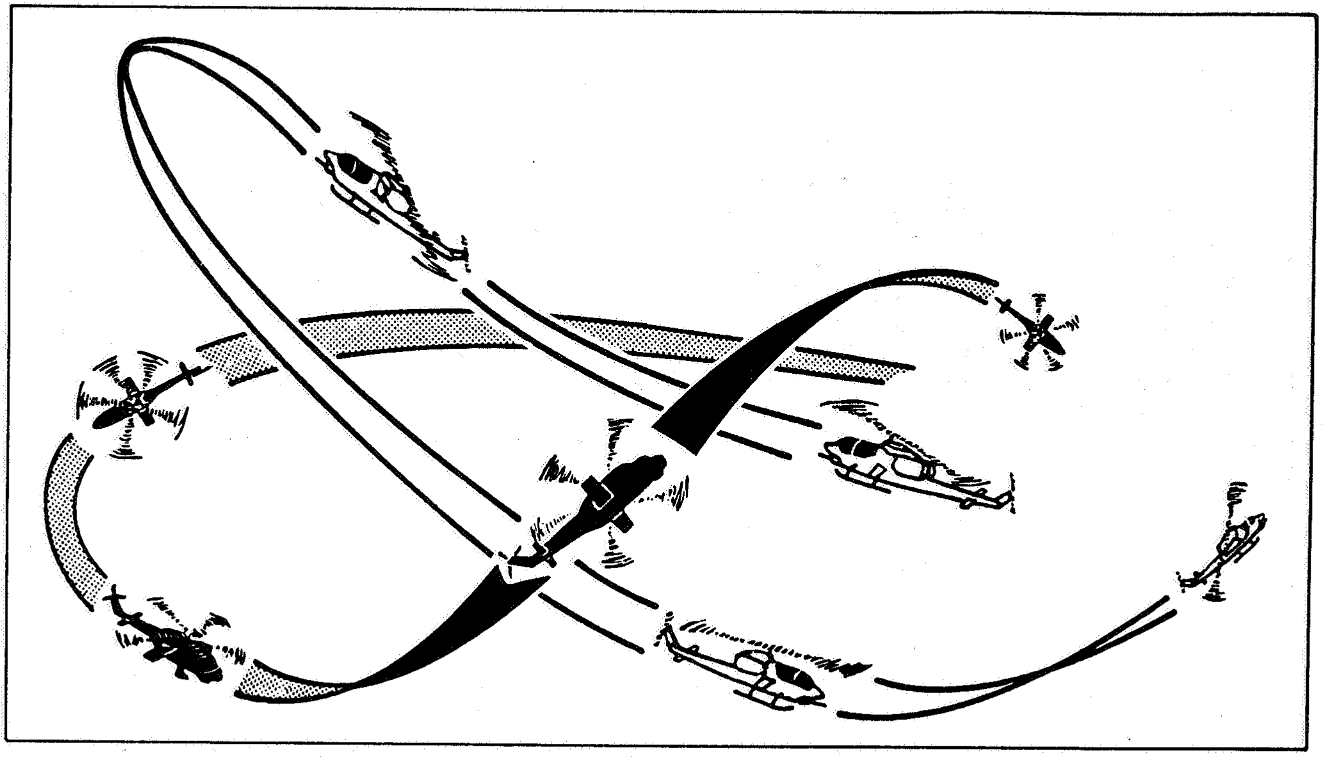


Figure 12-3. Countering the High Yo-Yo

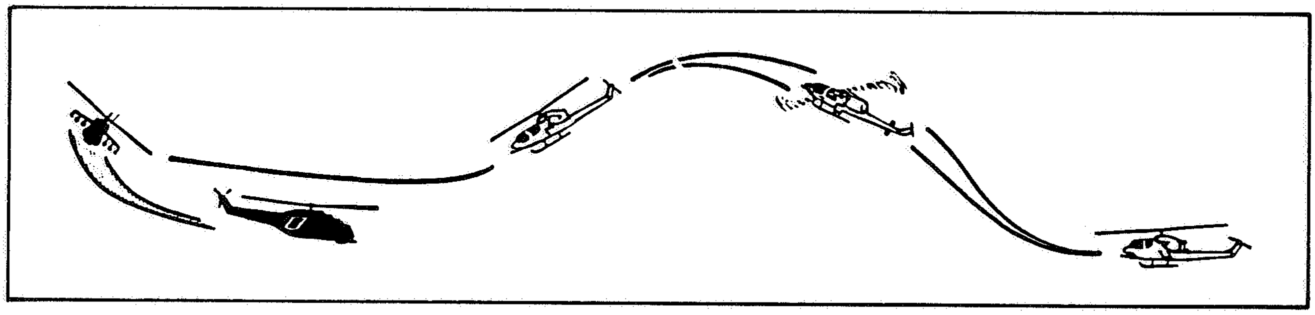


Figure 12-4. Wing-Over Attack

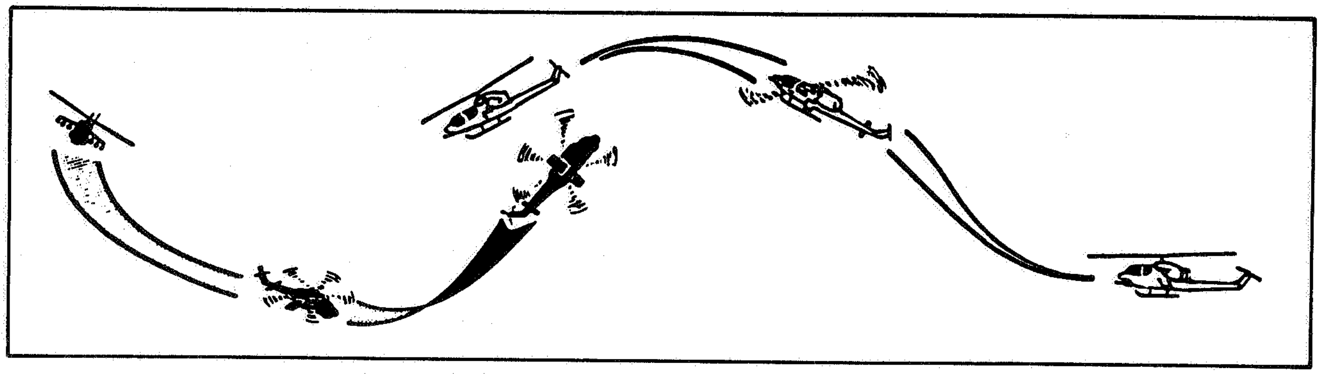


Figure 12-5. Countering the Wing-Over Attack

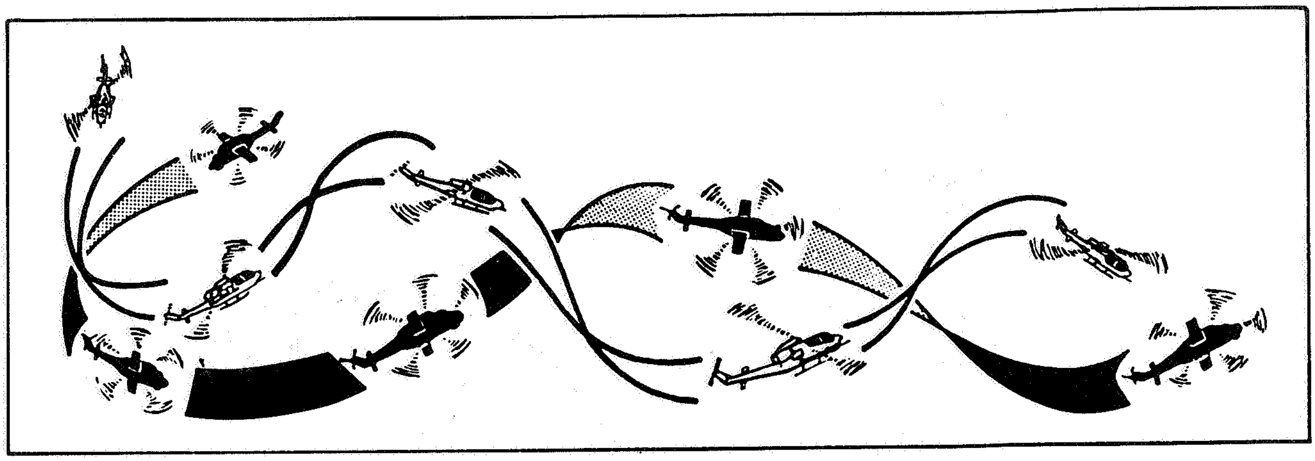


Figure 12-6. Scissors

will close and speed will increase. The maneuver should terminate with enough speed to complete a climb to the tail-chase position. This maneuver can be repeated to close to the desired nose-to-tail separation (Figure 12-7).

12.3.2.1.8 Countering the Low Yo-Yo. Counter the low yo-yo by turning and diving toward the attacker the instant he starts his maneuver in an attempt to meet him head-on. If an immediate turn-in is not made, the enemy will rapidly reduce angle-off and range.

With sufficient maneuvering speed, another defense is to pull up and roll into the enemy as in a wing-over maneuver.

12.3.2.1.9 Side-Flare Quick Stop. The side-flare quick stop is a defensive maneuver designed to cause an overshoot by the adversary. For the maneuver to be effective, however, the attacker will have to be *within* 500 feet of nose-tail separation. The side-flare quick stop is performed to give the appearance of a turn while decelerating and maintaining a straight non-turning flight-path. To accomplish the maneuver:

1. With the opponent astern (less than 500 feet), initiate a rapid transition to a wing-down opposite rudder configuration.

2. While in this position, rapidly reduce power while maintaining a side-flare attitude.

When your opponent is committed to an overshoot, accelerate the aircraft and maneuver to the optimum tail-chase position and/or to weapons delivery parameters if armed.

12.3.2.1.10 Defense Against the Side-Flare Quick Stop. The result of a side-flare quick stop is a low-energy state with little chance of regaining airspeed or altitude rapidly. To defend against this maneuver, maintain energy and use an out-of-plane maneuver to mask the aircraft from enemy weapons. Maintain the advantage by preventing an overshoot, and position the aircraft for a look-down advantage.

12.4 FORMATION FLIGHT

Tactical formations make use of cruise principles and are dependent on METT. The

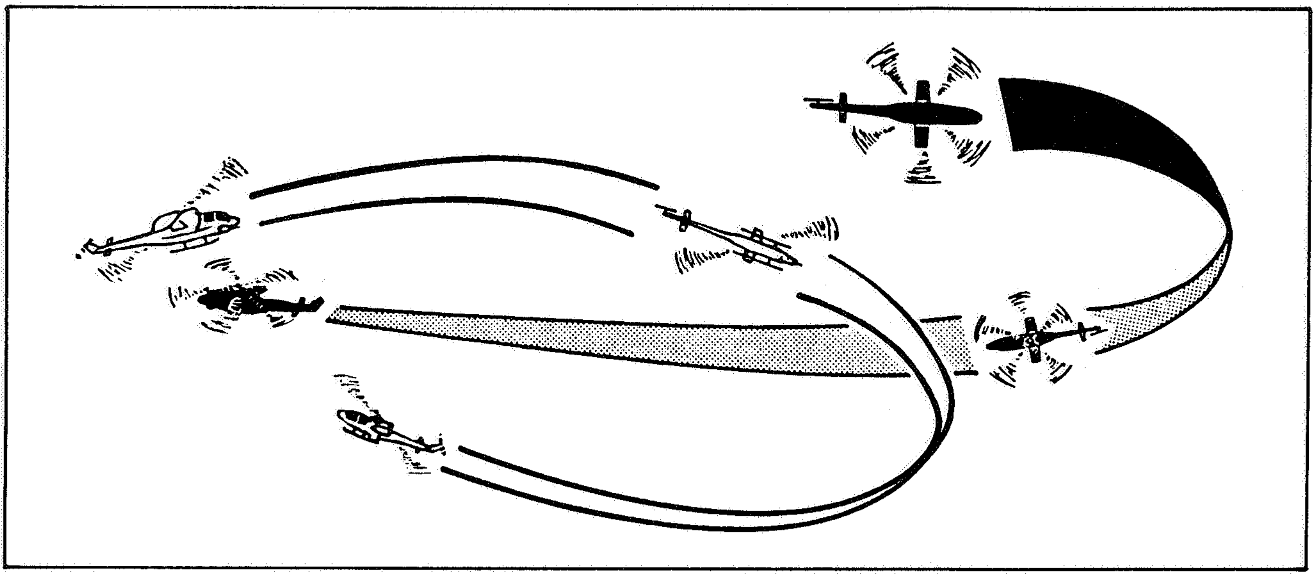


Figure 12-7. Low Yo-Yo

basic tactical unit is the section. No matter what size the formation, the section building block is the basis for its successful employment. There are two basic tactical formations: combat cruise and combat spread.

12.4.1 Combat Spread. Combat spread is the basic formation used by flights of armed helicopters in the conduct of their mission. Maneuvering in combat spread is accomplished using radius of turn and altitude advantage to maintain/regain position in the flight. Exceptions are necessary when a flight is required to execute a break. (Figure 12-8.) This information maximizes lookout doctrine, mutual support, flight control, and flight leader flexibility.

12.4.2 Combat Cruise. Combat cruise is the formation normally used by attack helicopters when flying in the contour/NOE mode. The concept of increased flexibility for the wingman is a driving consideration in this formation. Released from the need to maintain a precise position, the wingman can concentrate on terrain flight, navigation, mutual support, as well as enemy detection and avoidance. Maneuvering in combat cruise is accomplished in much the same manner as combat spread. During maneuvering flight, the wingman may position himself anywhere between 10° forward of the 0° bearing to 60° aft, either side of lead. Flight in the 60° cone of lead's 6 o'clock is restricted to side-to-side transitions only. Terrain and the tactical situation affect the distance and bearing of the wingman. The wingman is charged with responsibility for the 6 o'clock sweep. This sweep is designed to prevent surprise attack from the rear. When the lead aircraft changes flight direction, the wingman's cruise techniques will accomplish the clearing sweep. When flying over open terrain a series of small (10°) check-turns by the flight will suffice.

1. Section Combat Cruise. In the section, the optimum position for the wingman is the 45° bearing, with a minimum of 500 feet of

horizontal separation and level with lead. Unless otherwise dictated, the wingman should position himself where he can best cover the lead aircraft. In rough terrain, where both the section's and enemy's fields of fire are restricted, the formation should be much tighter than when crossing open areas. Under normal conditions, the wingman should remain closer to the 45° bearing. When maximum observation or firepower to the front is required, the wingman will move closer to the comabt spread position.

2. Division Combat Cruise. The four aircraft combat cruise is a combination of two sections. The second section leader will position his aircraft a minimum of 1500 feet out on the 30° bearing off lead. During maneuvering flight, the second section positions itself where mutual support is best attained and is free to cross from side to side as terrain and situation dictate. The lead section wingman will balance the fight whenever possible. The section procedures remain the same. When flying three aircraft division, combat cruise formation can be comprised of either heavy section, heavy forward, or heavy aft, as situation dictates. In any case, the third aircraft flies as a simulated section. (See Figure 12-9.)

12.5 FORMATION MANEUVERING

12.5.1 Combat Cruise. Normal cruise principles can be used for most turns in the combat cruise position. *Break turns* or turns effected to face an enemy attack are easy to manage from the basic combat cruise position if the concepts of military and tactical lead are understood. The military leader is the designated formation leader responsible for organization and control of the flight. The tactical lead is the aircrew with the lead position or best *tactical grasp* of the situation. It is independent of rank, experience, or ability. During an attack, it is normally the engaged aircraft. For example, if a section is in combat cruise with a right echelon alignment and the flight must *break right,*" then the wingman automatically assumes the tactical lead, and the military leader will ensure separation.

As the position in combat cruise varies from the optimum, turns must be adjusted so as not to present a linear target during *break turns*.

12.5.2 Combat Spread. There are four basic tactical turns from combat spread: check turns, tac turns, cross turns, and in-place turns. These turns also apply at times when the flight in combat cruise approaches the combat spread position (Figures 12-10 through 12-18).

No matter what the maneuver, all signals must be prebriefed and clearly understood prior to flying the mission. Prebriefed angles of bank and power settings should be established for each maneuver. Use of cruise principles to the extent possible conserves fuel and simplifies maneuvering.

12.6 SECTION TACTICS

Since the basic maneuver element for helicopters is a section, it is imperative that helicopter pilots become as familiar as possible with section tactics. The individual maneuvers and concepts previously discussed still apply. The tactical approach used is flexible and lends itself to any formation. Section tactics are dependent on bogey acquisition. The range and aspect of the initial acquisition will determine the tactics used. The following planning steps should be used when an air threat is anticipated:

1. When possible, the flight should consist of two, but never more than three, aircraft. It is best to maintain section integrity because of the positive aspects of mutual support, improved lookout capability, simplified planning and control, and mission requirements of the supported unit.

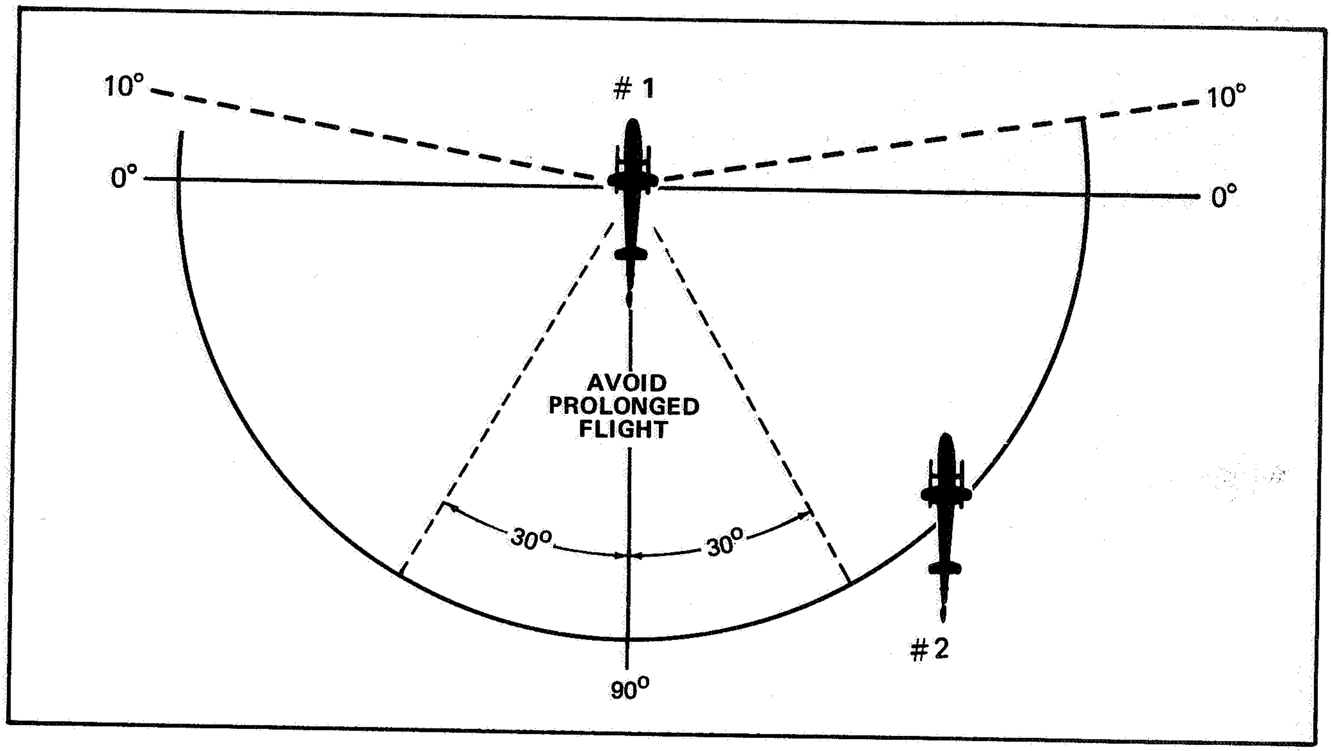


Figure 12-8. Combat Spread

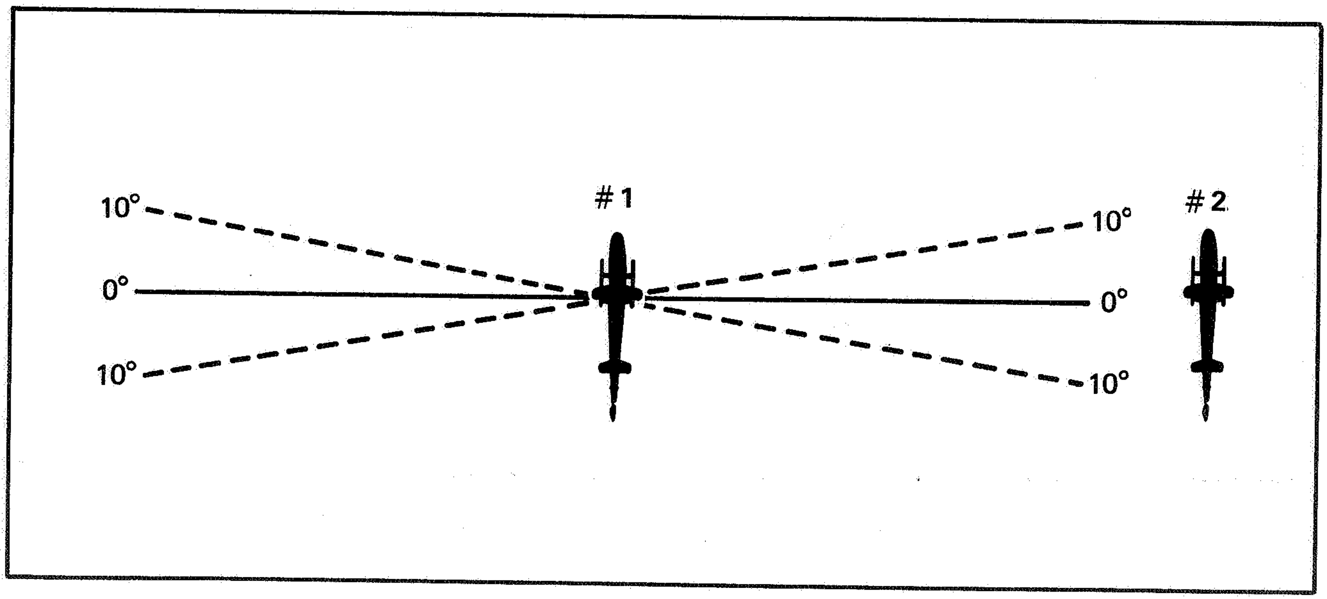


Figure 12-9. Combat Cruise

Check turns are from 30° to 60° of heading change and can be performed with or without radio communication. A check turn away from the wingman requires the wingman to initiate a turn into lead after the call or signal is received. After the wingman is established in the turn (about 20° to 30° of heading change), lead turns and then rolls out on course. The wingman then rolls out and resumes the bearing.

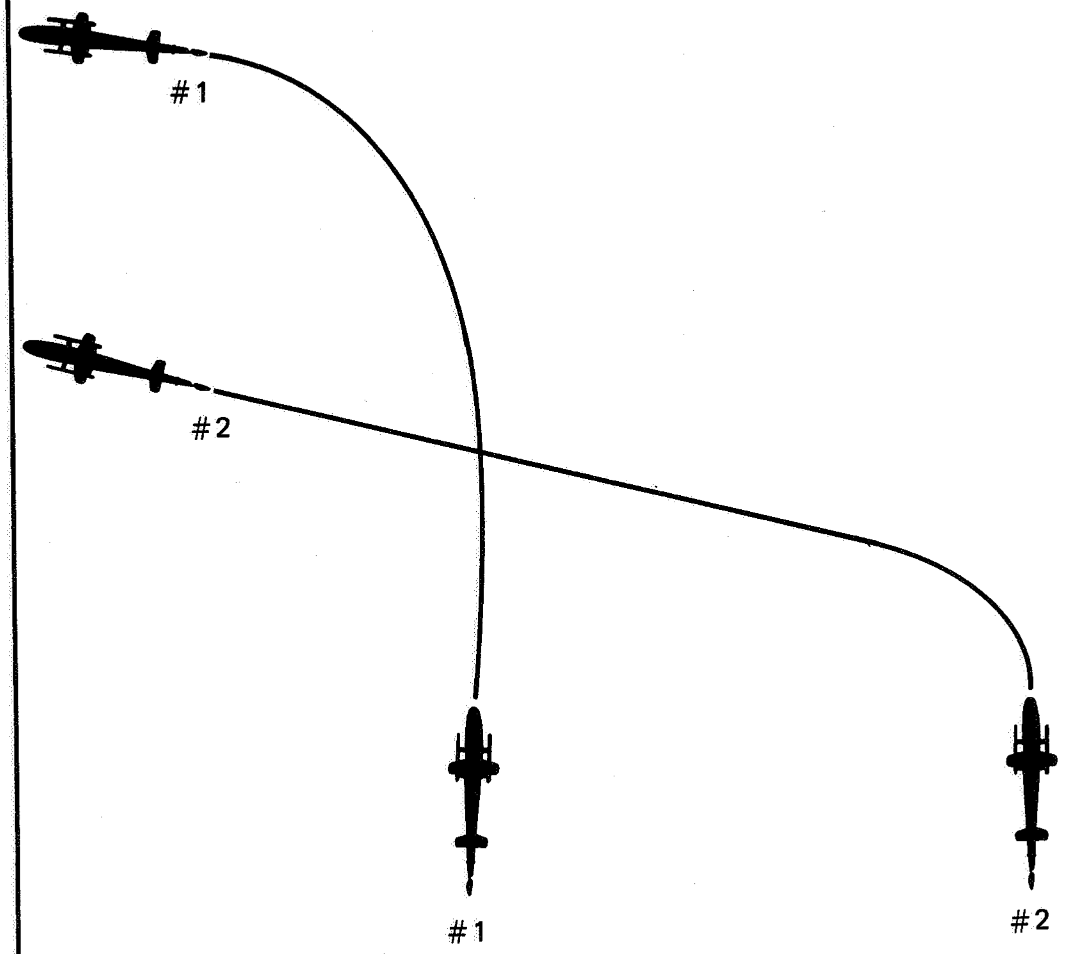


Figure 12-10. Check Turn Away From the Wingman

For a check turn into the wingman, lead simply turns to the new course. The wingman continues his flightpath until lead rolls out and then turns into the leader so as to cross his flightpath at a 90° angle. As lead passes thorugh the wingman's 4 to 5 or 7 to 8 o'clock position, the wingman turns to the new course and resumes the bearing.

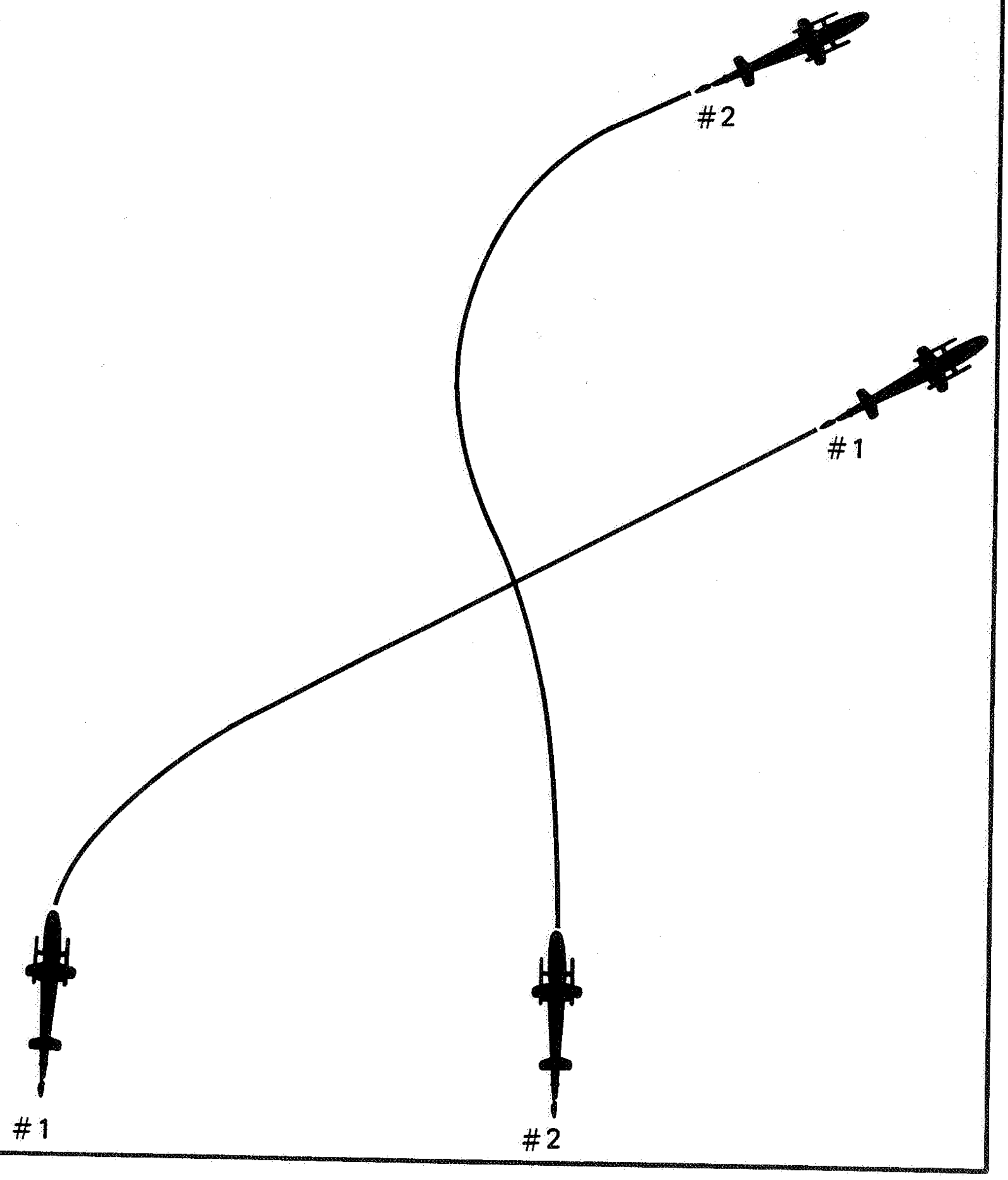


Figure 12-11. Check Turn Into the Wingman

Tac turns are from 60° to 120° of turn and can be performed with or without radio communication. A tac turn away from the wingman requires lead to hold his heading after transmitting the signal. As the wingman approaches the lead's 4 or 8 o'clock position, lead turns to the new heading.

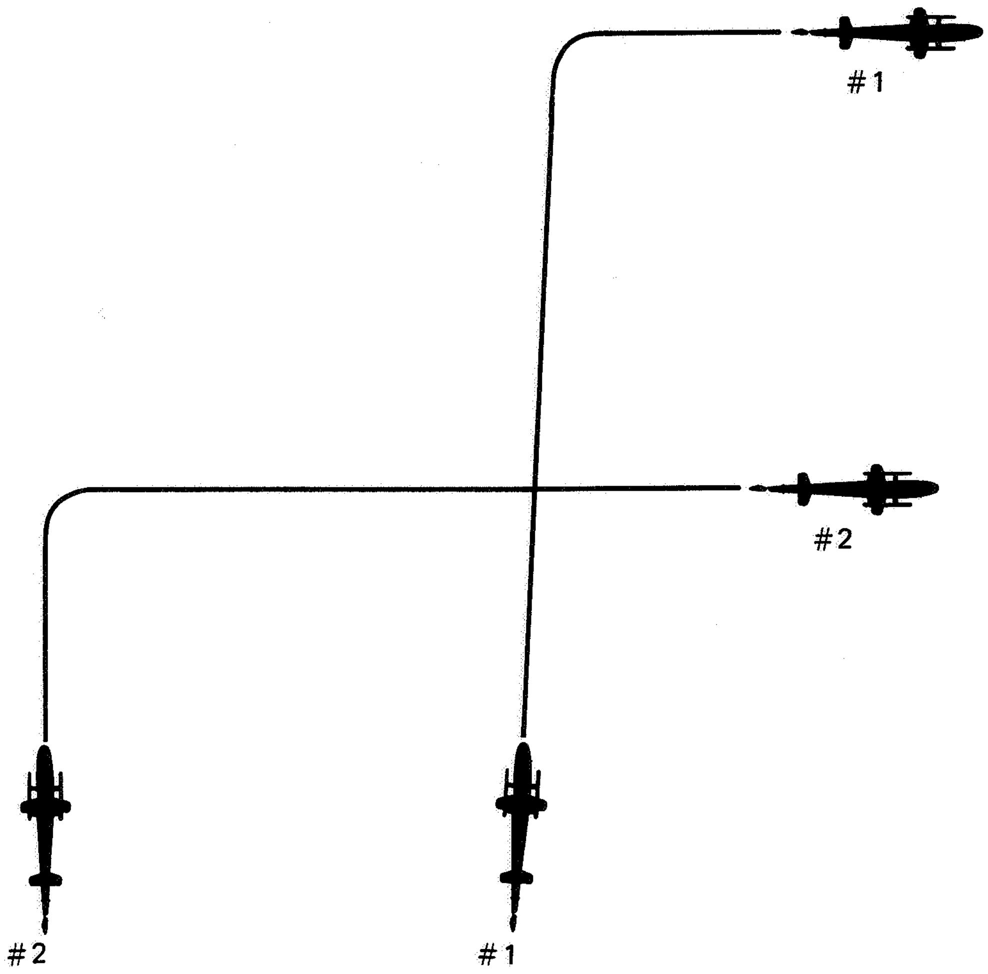


Figure 12-12. Tac Turn Away From the Wingman (Combat Spread)

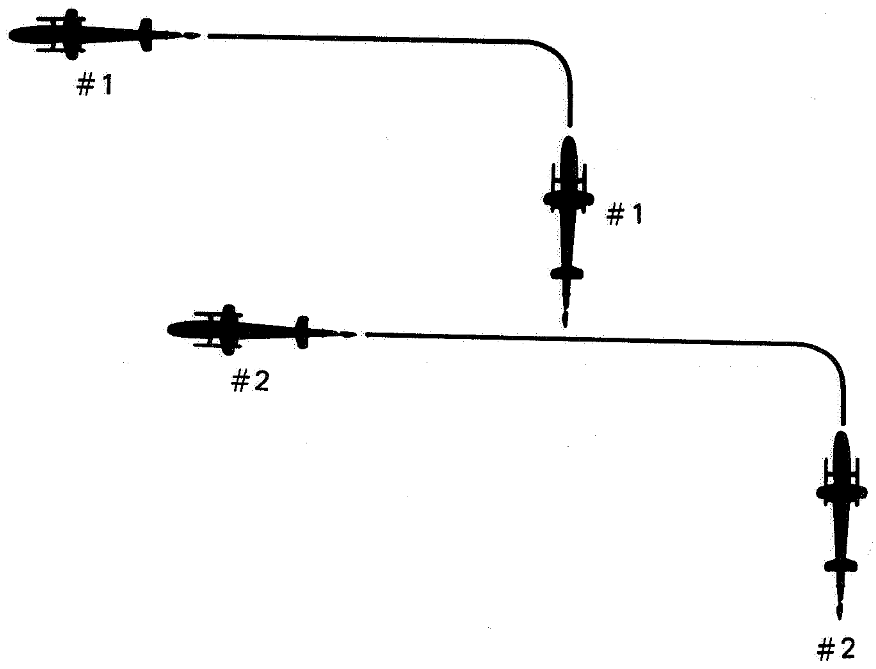


Figure 12-13. Tac Turn Away From the Wingman (Combat Cruise)

For a tac turn into the wingman, the lead turns to the new heading and rolls out immediately after the signal. The wingman holds his heading until lead passes through the 4 or 8 o'clock position, then the wingman turns to the new heading and resumes the bearing.

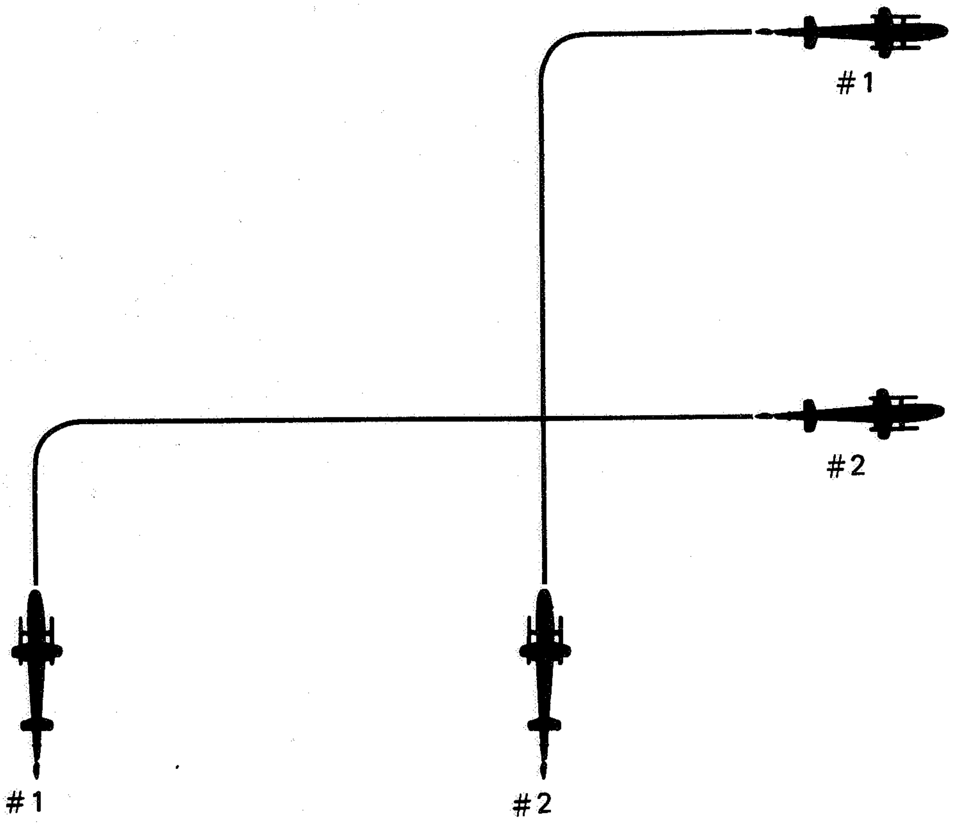


Figure 12-14. Tac Turn Into the Wingman (Combat Spread)

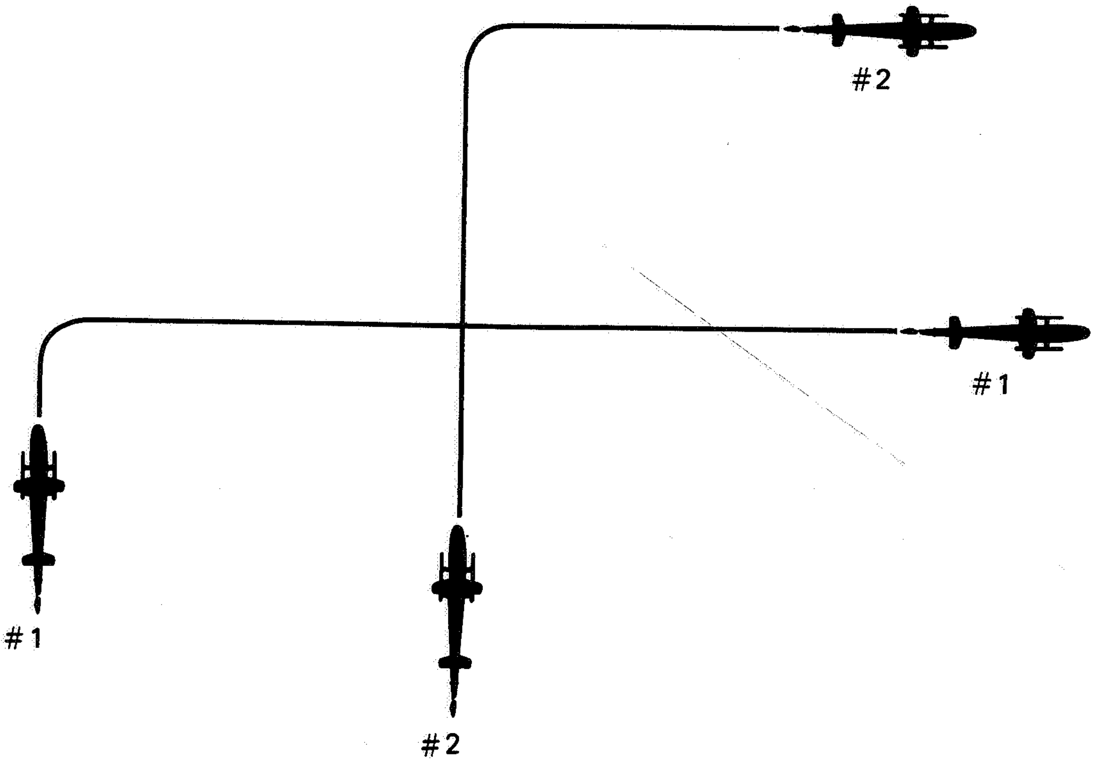


Figure 12-15. Tac Turn Into the Wingman (Combat Cruise)

Cross turns are turns of 120° to 240° of heading change that can be performed with or without radio communications. This turn can be used to reverse the section's heading in channelized terrain. After the signal, the leader turns into the wingman. As soon as the leader has completed 20° to 30° of heading change, the wingman begins his turn into the leader. Initial separation will determine the angle of bank necessary to reestablish each aircraft on the new heading with desired separation.

Note

For no comm cross turn, lead gives a *Wing Flash* and then turns into the wingman.

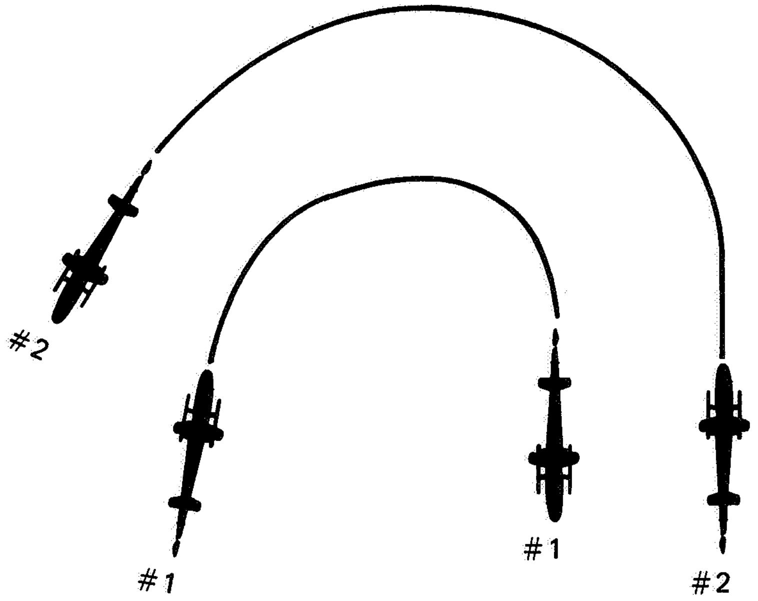


Figure 12-16. Cross Turn

In-place turns are turns of 120° to 240° of heading change that are performed with or without radio communications. The turn is initiated by an in-place port or starboard call. Both aircraft turn in the direction indicated by the call. Angle of bank and power must be maintained as briefed so the wingman should be in trail at the 90° position. At the completion of the turn, the bearing is resumed. Maintain as much energy as possible.

Note

For no comm in-place turn, lead raises his noise 10° (not to climb more than 50 feet) and then commences his turn.

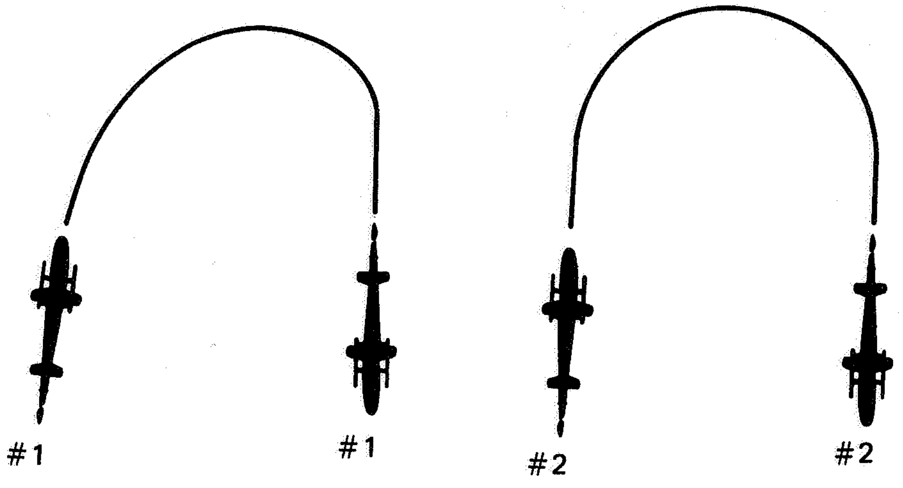


Figure 12-17. In-Place Turn

The dig/pinch is a maneuver to initially separate the flight and then have the individual aircraft coverage 45° out of phase. Upon the command "Dig, Go," both aircraft take a 30° cut away from the flightpath. Upon the command "Pinch, Go" each aircraft immediately turns approximately 45° back to the target/bandit Figure 12-18).

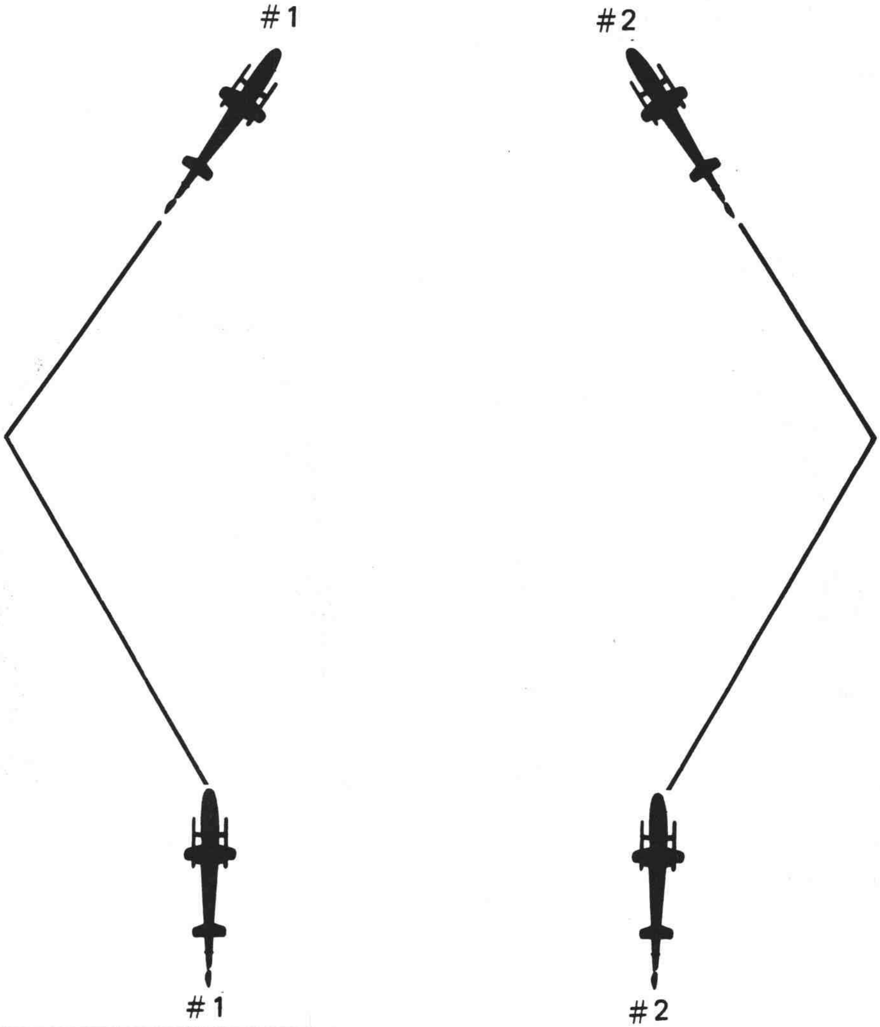


Figure 12–18. Dig/Pinch

2. Decide in advance whether the situation and mission dictate maintaining section integrity, use of a scatter plan, or both. The evasive break and/or scatter plan should be thoroughly briefed and understood prior to training or actual flight.

3. When escort aircraft are present, ensure the evasive break plan is coordinated with, and complements, the capabilities of the escort.

4. Control measures such as rendezvous points, rendezvous times, checkpoints, phaselines, abort criteria, and signals should be considered.

12.6.1 Formation Rules of Thumb

1. Do not fly in a tight group and do not present a large linear target.

2. Escort aircraft should make every effort to prevent enemy aircraft from penetrating the formation and attacking the more vulnerable transport helicopters.

3. When engagement by an air threat is imminent, the transport helicopters should immediately descend and try to break visual contact by using terrain masking techniques.

12.6.2 Formations and Roles. When it is necessary to perform section evasive maneuvers, it is best to think of the section as a team, rather than a formation. Each member of the flight assumes a *role* depending upon which aircraft is engaged. These roles occur only during an engagement. The *military lead* is the designated section leader and is responsible for the success of his mission. During engagements, the engaged aircraft will become the *tactical lead* and the free aircraft will function as his *tactical wingman.* The military leader never changes. The predominent theme during an engagement is mutual support through improved lookout, control, positioning, and, when possible, weapon support. The following descriptions apply:

1. Mutual support is dependent on lookout doctrine and aircraft positioning.

   (a) Lookout doctrine — should be designed to provide 360° of visual coverage by well-trained and disciplined crewmen.

   (b) Aircraft positioning should maximize lookout capability, minimize exposure to threat aircraft, and prevent the section from being attacked as a single unit.

Note

Excessive separation may degrade mutual support and may result in the section being attacked as two separate targets.

2. Formations by definition are rigid and during extensive maneuvering are hard to fly. Hard pilot workload degrades lookout, decreases situational awarness, and causes predictability.

3. Roles promote flexibility, lookout, and situational awareness through proper aircraft positioning and timing. There are two engagement roles: free and engaged. This is based on the assumption that during a two versus one, two versus two, or two versus many engagement, one aircraft is under attack while the other is not.

4. Roles of engaged and free aircraft

   (a) Engaged role responsibilities:

   KILL THE BANDIT
   KEEP SIGHT OF BANDIT
   REMAIN UNPREDICTABLE
   DENY WEAPONS EMPLOYMENT
   FORCE BANDIT TO LOSE SIGHT
   CLEAR OWN SIX

   (b) Free roll responsibilities

KILL THE BANDIT
TRACK ENGAGED A/C AND BANDIT
CLEAR ENGAGED AND OWN SIX
MAINTAIN ENERGY
BREAK PHASE WITH FIGHT
MANEUVER TO DIRECT FIGHT

12.6.2.1 Utilizing Roles During an Engagement. The engagement begins when the attacker rolls in and chooses a specific target. The target or engaged aircraft should begin maneuvering and transmit that he is engaged. The aircraft not under immediate attack (free aircraft) should be positioned to support the engaged aircraft either visually or with weapons. The free aircraft should maintain a position to prevent the engaged aircraft from becoming isolated. It is possible for the roles to change many times during sequential attacks. The engaged aircraft always assumes the tactical lead. Air-to-Air maneuvers should attempt to create a two helicopter versus one adversary situation during engagements and attempt to drive the flight in the most advantageous direction for survivability and mission accomplishment. In general, the free helicopter should maneuver to break phase with the flight and maintain visual contact with all threat aircraft and the engaged helicopter in order to direct the fight, and if possible, employ weapons against the threat aircraft. The following objectives apply:

1. Disengage — force the bandits to lose sight through the use of terrain masking, shadows, and so forth.

2. Drive the fight — move the engagement in the direction to:

   (a) Disengage.

   (b) Cause engagement of the enemy by supporting arms.

   (c) Position the enemy at a disadvantage.

   (d) Continue with the mission.

12.6.2.2 Fixed-Wing Tactics. There are many types of attacks by fixed-wing adversaries. Two points are common:

1. Most attempt to align both targets.

2. Most attack out of phase with each other.

The following are typical fixed-wing attack tactics:

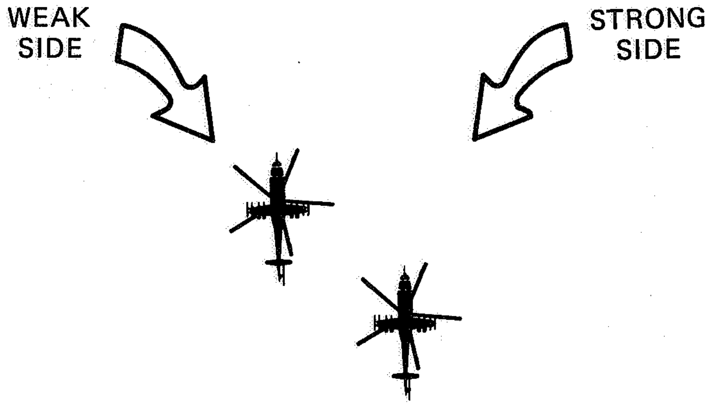
1. Double horizontal — uses both fixed-wing aircraft in the same horizontal plane and attacks with approximately 90° to 120° of separation. This tactic allows the helicopter to easily maintain sight of the fixed-wing aircraft.

2. Split plane — allows the fixed wing to attack out of plane and out of phase simultaneously while using different types of ordnance (i.e., guns or bombs). Situational awareness is difficult to maintain and loss of sight commonly occurs, especially with the high bandit.

3. Extension — the fixed-wing section splits with one aircraft, maintaining sight while the other extends beyond visual range, reentering the fight with vector from his wingman.

12.6.3 Section Tactics Against Armed Helicopters. The basic concepts for section tactics against armed helicopters are the same as for those against a fixed-wing threat. Aircraft roles rather than rigid formations, are used for mutual support. Once an engagement has commenced, expect roles to change much more rapidly than in a fixed-wing engagement. The following principles apply:

1. Weak-side attack — once it is obvious that an engagement cannot be avoided, maneuver to the weak side of the enemy formation in an effect to mask enemy fires (Figure 12-19).



EXAMPLE: The weak side of an echelon formation is the side or angle which exposes friendly aircraft to the smallest threat; i.e., one threat aircraft is masked by the other, as shown above.

Figure 12-19. Weak Side

2. Split-plane maneuver — split-plane maneuvering will cause difficulty in tracking for the threat section. Splitting the defending section by altitude should force the threat aircraft to commit their attack to only one aircraft.

3. Roles of engaged and free aircraft

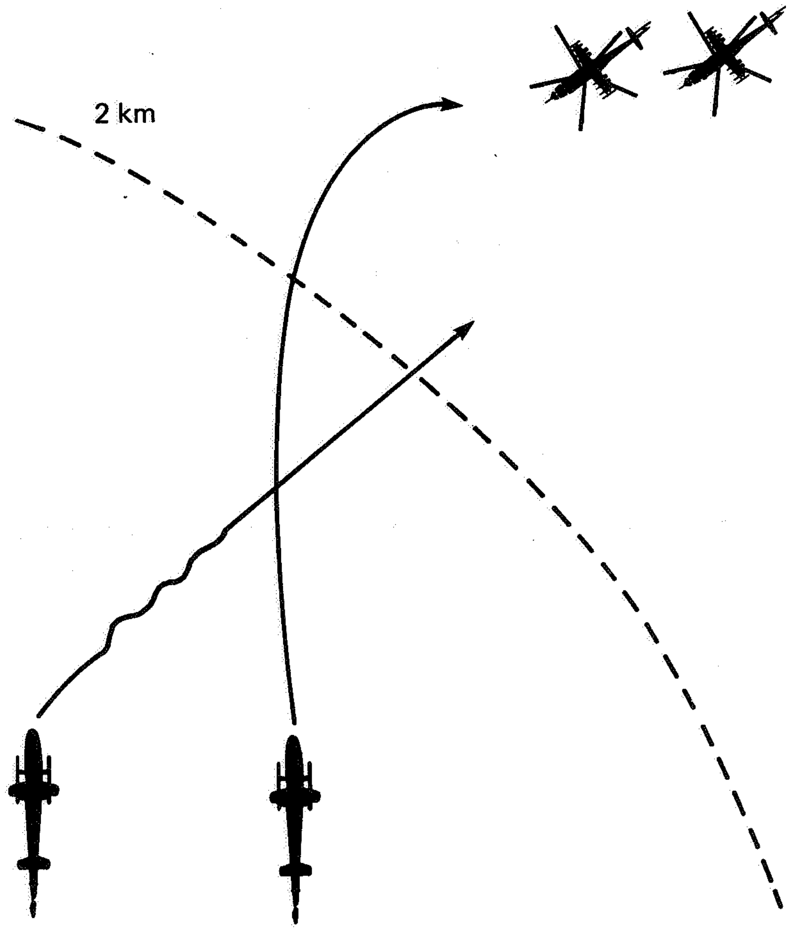
(a) Engaged role responsibilities:

KILL THE BANDIT
KEEP SIGHT OF THE BANDIT
MAKE THE BANDIT PREDICTABLE
DENY THE BANDIT WEAPONS EMPLOYMENT
FORCE THE BANDIT TO LOW ENERGY STATE
FORCE THE BANDIT TO A LOWER ALTITUDE
CLEAR YOUR OWN SIX

(b) Free role responsibilities:

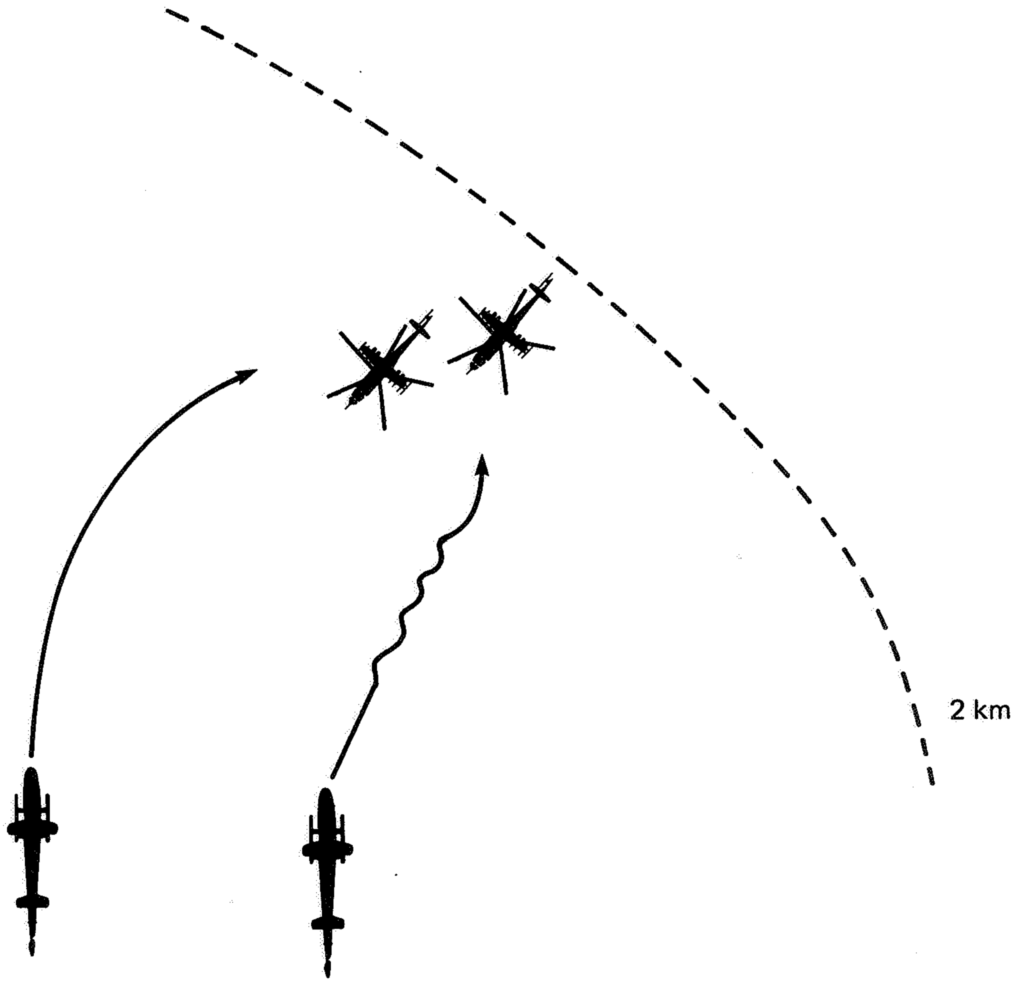
KILL THE BANDIT
KEEP TRACK OF FIGHT
CLEAR ENGAGED SIX AND YOUR OWN SIX
MAINTAIN ENERGY LEVEL
BREAK PLANE AND PHASE WITH FIGHT
MANEUVER TO BANDIT'S BLIND SIDE
DIRECT THE FIGHT

4. Engagement quadrants — Figures 12-20 through 12-27 are examples of the proper initial maneuvers for a section of helicopters forced to engage threat armed helicopters from various quadrants.



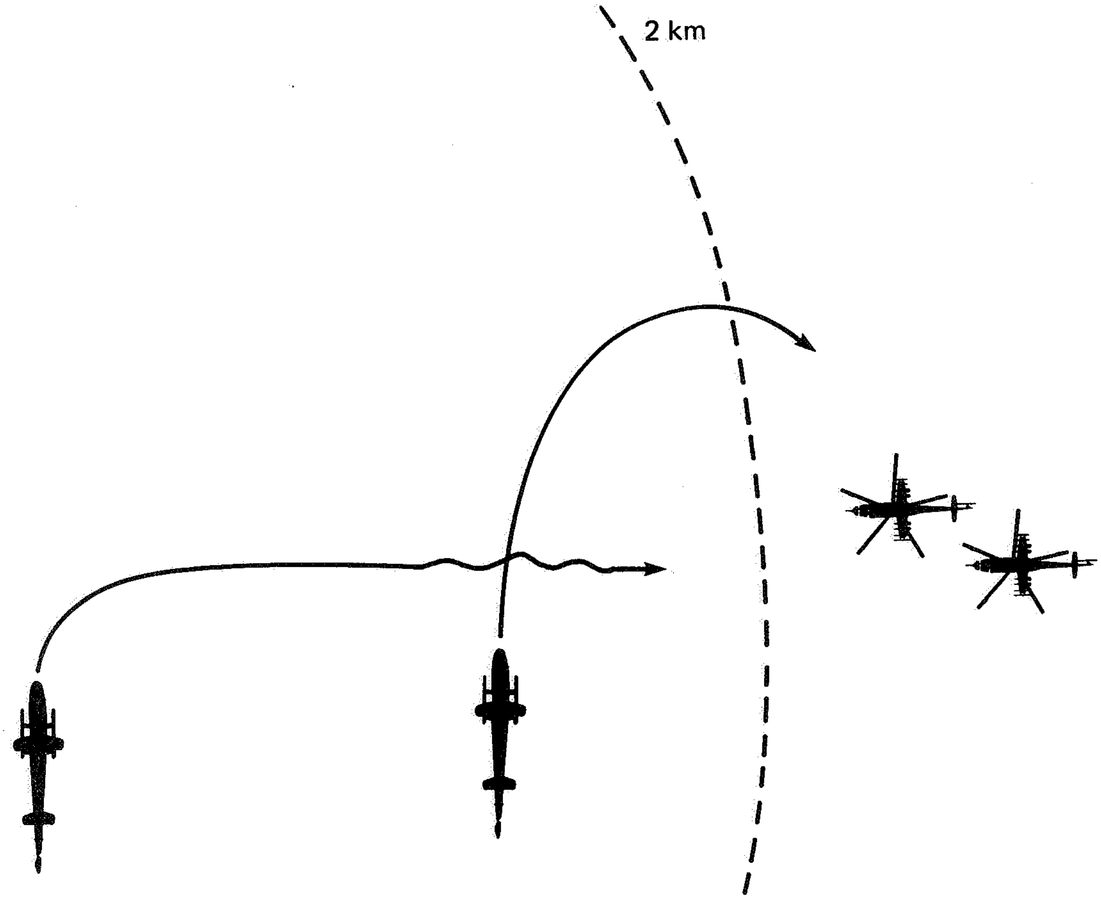
When a forward quarter engagement begins beyond 2 km, it is usually possible to designate the nearest aircraft (the AH-1 on the right), as the engaged helo. The engaged helo should turn and utilize head-on air-to-air tactics while the free helo maneuvers to satisfy his role requirements. Generally, all engagements commencing at ranges grater than 2 km will turn into a nose-to-nose-engagement.

Figure 12–20. Forward Quarter Attack Outside 2 km



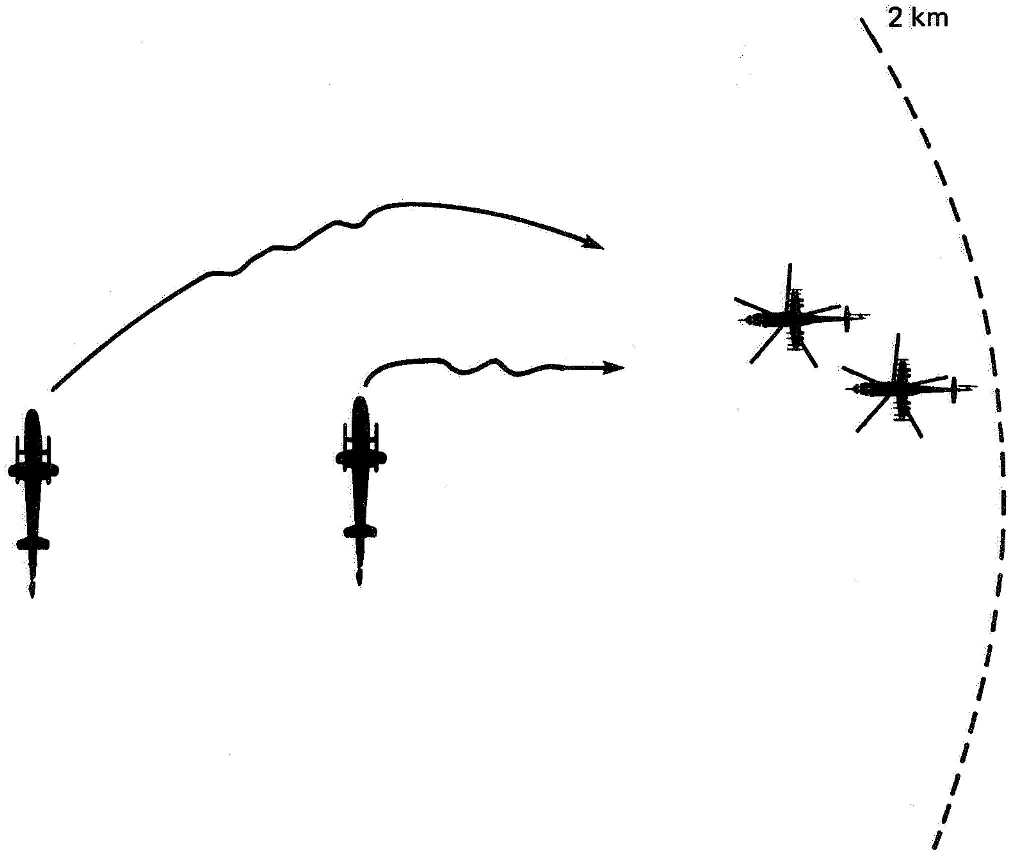
If acquisition of the attacking section occurs inside of 2 km, it may be difficult to determine which defender will be engaged. Both defenders should maneuver to split plane and phase. Once the engaged helo is determined, appropriate role responsibilities apply.

Figure 12-21. Forward Quarter Attack Inside 2 km



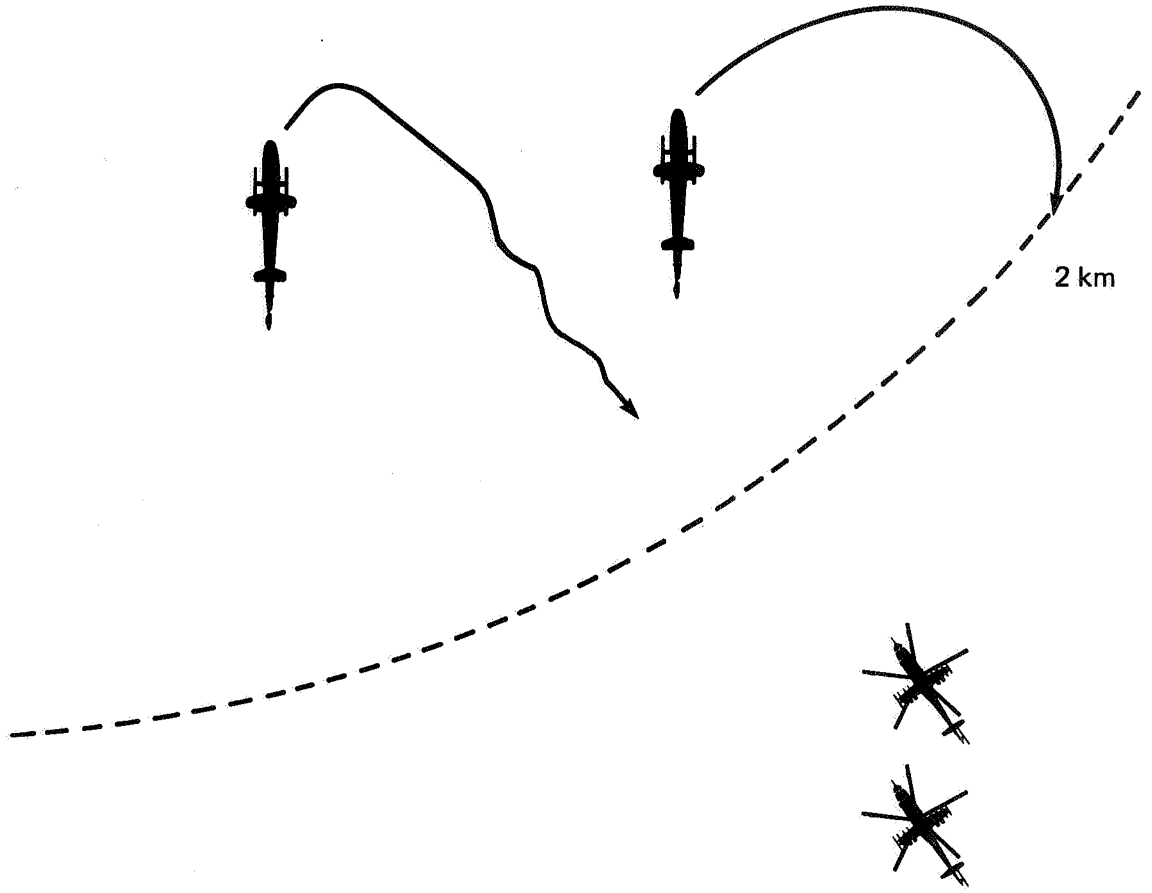
In most cases, an abeam encounter presents the attacker with an almost linear target. It is essential to maneuver the section to acquire separation between aircraft (relative to the attackers) to force the attacking helicopters to commit their attack to a specific aircraft. Once the engaged helo is determined, appropriate role responsibilities apply. Generally, all engagements commencing at ranges greater than 2 km will turn into a nose-to-nose engagement.

Figure 12-22. Abeam Attack Outside 2 km



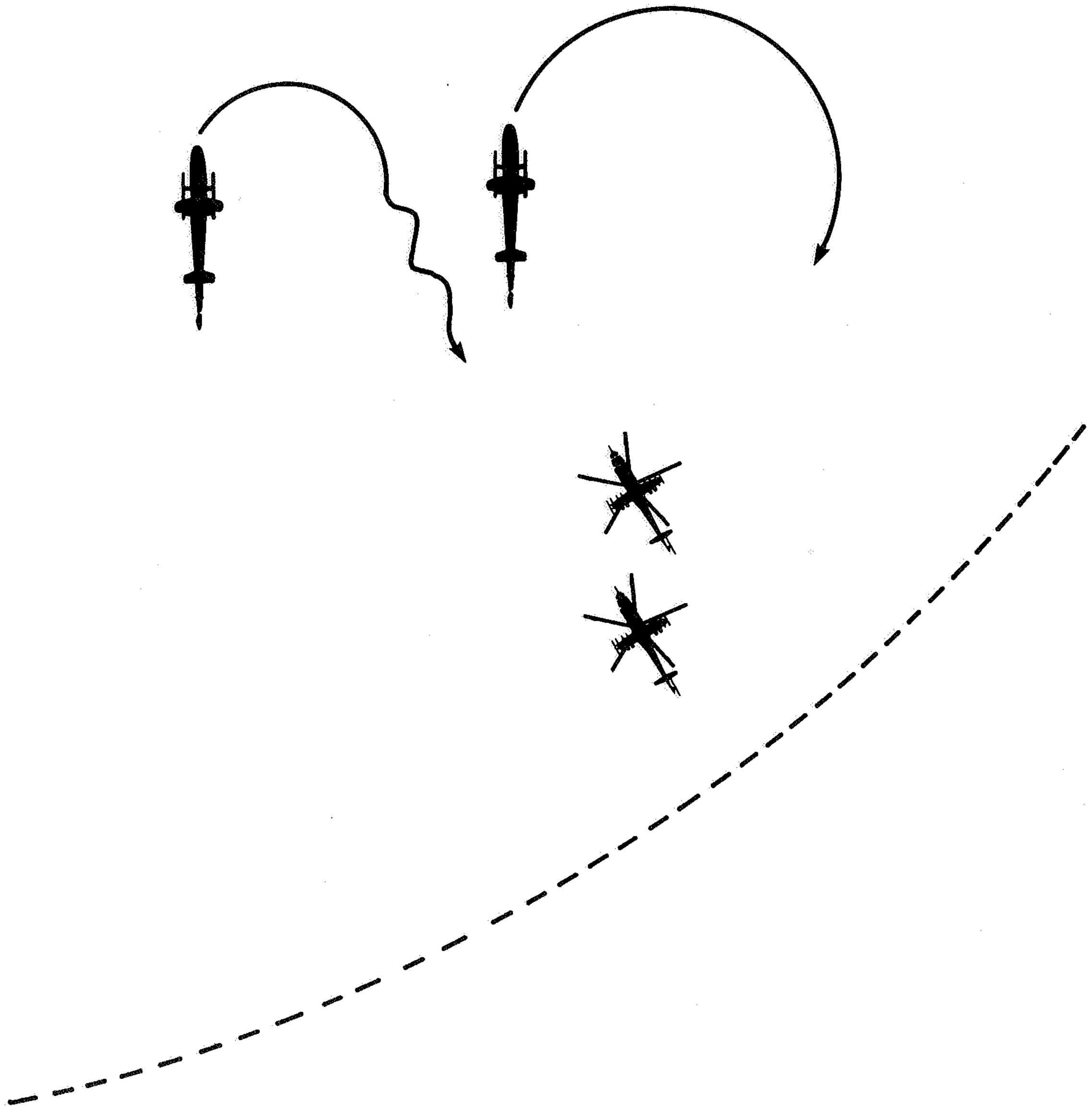
When an attack occurs from the abeam with 2 km, the close proximity and near linear aspect presented to the enemy requires immediate initiation of evasive maneuvers, including turns to separate and to break plane and phase. The aircraft closest must turn to reduce the possibility of making the flight linear. When the engaged helo is identified, appropriate role responsibilities apply.

Figure 12-23. Abeam Attack Inside 2 km



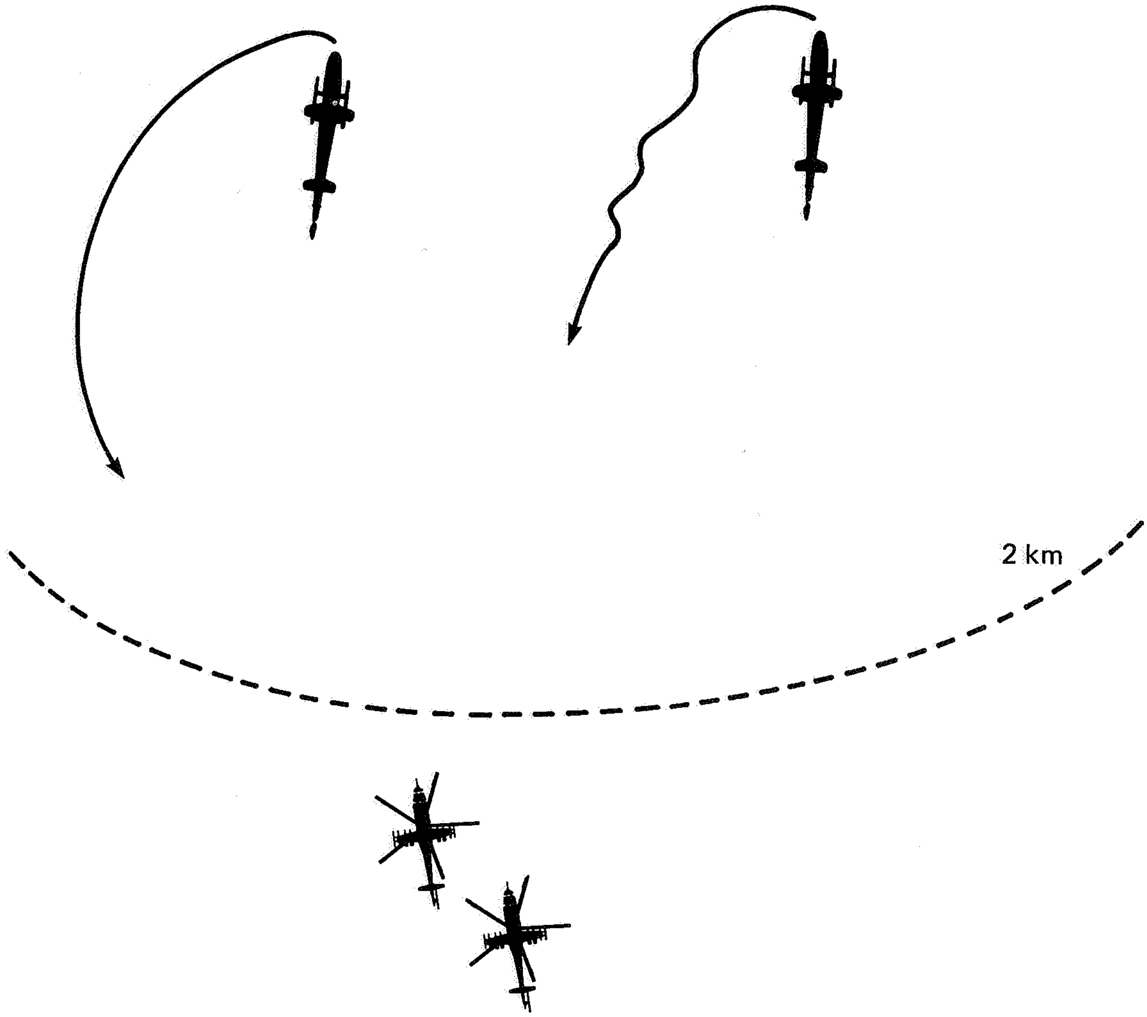
The flight should turn to achieve proper head-on orientation and approximately 1500 feet lateral separation. The engaged helo can then be determined. Generally, the aircraft nearest the adversaries should attempt to assume the free helo role in order to attempt an out-of-plane/out-of-phase counterattack. Generally, all engagements commencing at ranges greater than 2 km will turn into a nose to nose engagement.

Figure 12-24. Aft Quarter Attack Outside 2 km



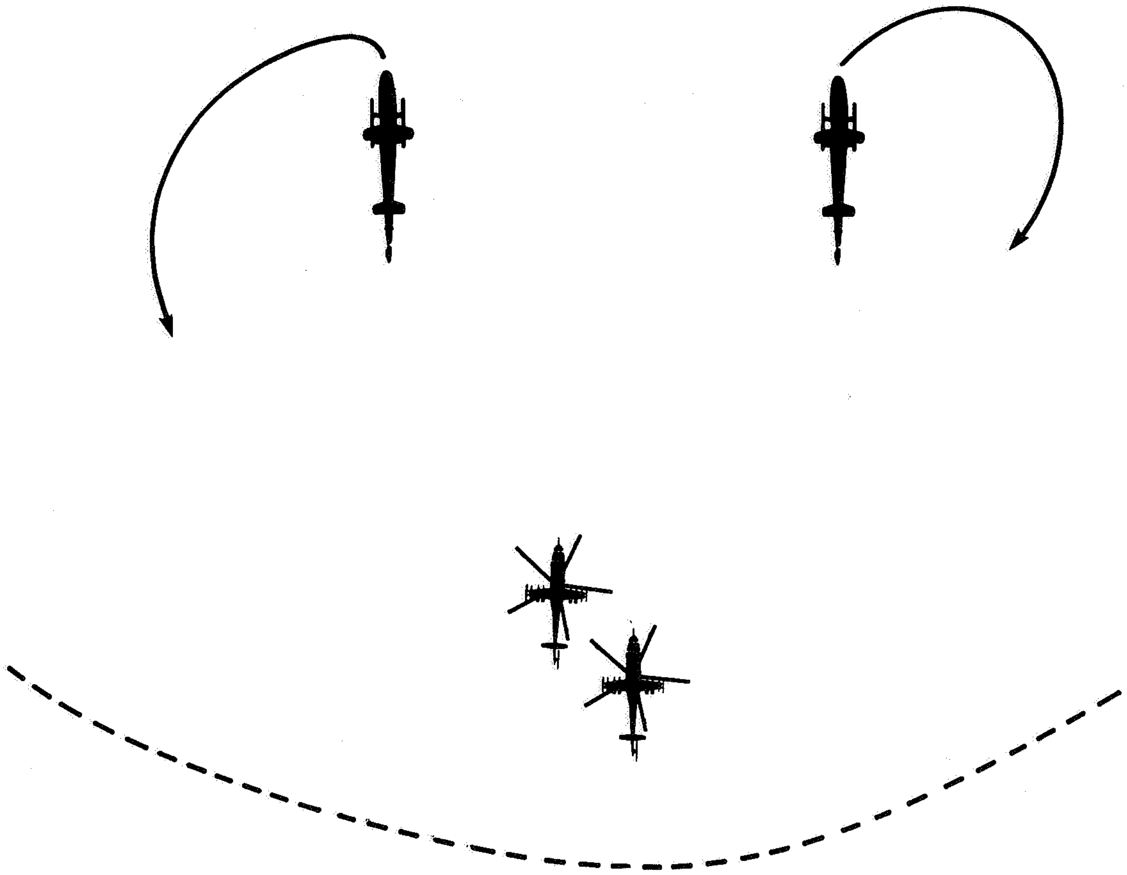
In this situation, the aircraft nearest the attacker should attempt to assume the free helo role. This allows the wingman to turn in the most advantageous direction. When the engaged helo is identified, the appropriate role responsibilities apply.

Figure 12-25. Aft Quarter Attack Inside 2 km



The flight should *break* turn toward the weak side of the attacking formation. This usually allows the flight leader to determine which aircraft will assume the engaged helo role. Generally, all engagements commencing outside 2-km turn into a nose-to nose engagement.

Figure 12–26. Stern Attack Outside 2 km



When attacked from less than 2-km astern, the section should break away from each other for 180°. This forces the attackers to be committed to engage one helicopter while exposed to the other. Once the engaged helo has been determined, appropriate role responsibilities apply.

Figure 12-27. Stern Attack Inside 2 km

PART IV

Enemy Defense and Friendly Countermeasures

Chapter 13 — The Threat

CHAPTER 13

The Threat

13.1 GENERAL

In most areas of the world, threat forces are mainly armored with many tanks, armored infantry fighting vehicles, self-propelled artillery, self-propelled and rapidly launched tactical bridging, and supporting mobile equipment. They are equipped with a full arsenal of modern air defense weapons which includes tactical aircraft, missiles, antiaircraft (AA) artillery, and vehicle-mounted machineguns.

Threat forces train extensively for operations in a nuclear battlefield and carry a complete array of individual and vehicular nuclear, biological, and chemical (NBC) protective gear and decontamination equipment. Most of their armored vehicles provide positive pressure protection for their crews. Further, threat forces conduct very effective electronic warfare (EW), including radio interception, direction-finding, jamming, and deception. Their emphasis on night/reduced visibility operations also has a significant effect on friendly air support operations.

Threat forces are large, well equipped, and well trained. Basically a mounted force, they are heavy in tanks and artillery. They protect their ground maneuver elements with a variety of antiaircraft weapons and employ helicopters and high performance aircraft both as offensive weapons and to provide protection for ground elements. Threat tactics stress massing weapons in depth to overpower the opposition, and these weapons are deployed to take advantage of their complementary capabilities.

Foreign military experts have devoted considerable attention to the continuation of high-tempo operations through periods of darkness, adverse weather, and CBR conditions for extended periods of time. The capability to conduct such operations is partly determined by the threat's speed, mobility, firepower, and reserves.

Various threat antiaircraft, ground, and aircraft weapons are discussed in this chapter in terms of strengths and weaknesses and are presented in certain tactical settings in order to provide a clearer picture of both weapons relationships and vulnerabilities open to exploitation.

It is noted that the composition of specific threat forces varies widely between nations and areas, with some being relatively unsophisticated and others being highly technical. Forces are normally task organized for particular missions so that, for each scenario, careful analysis of the METT factors is required.

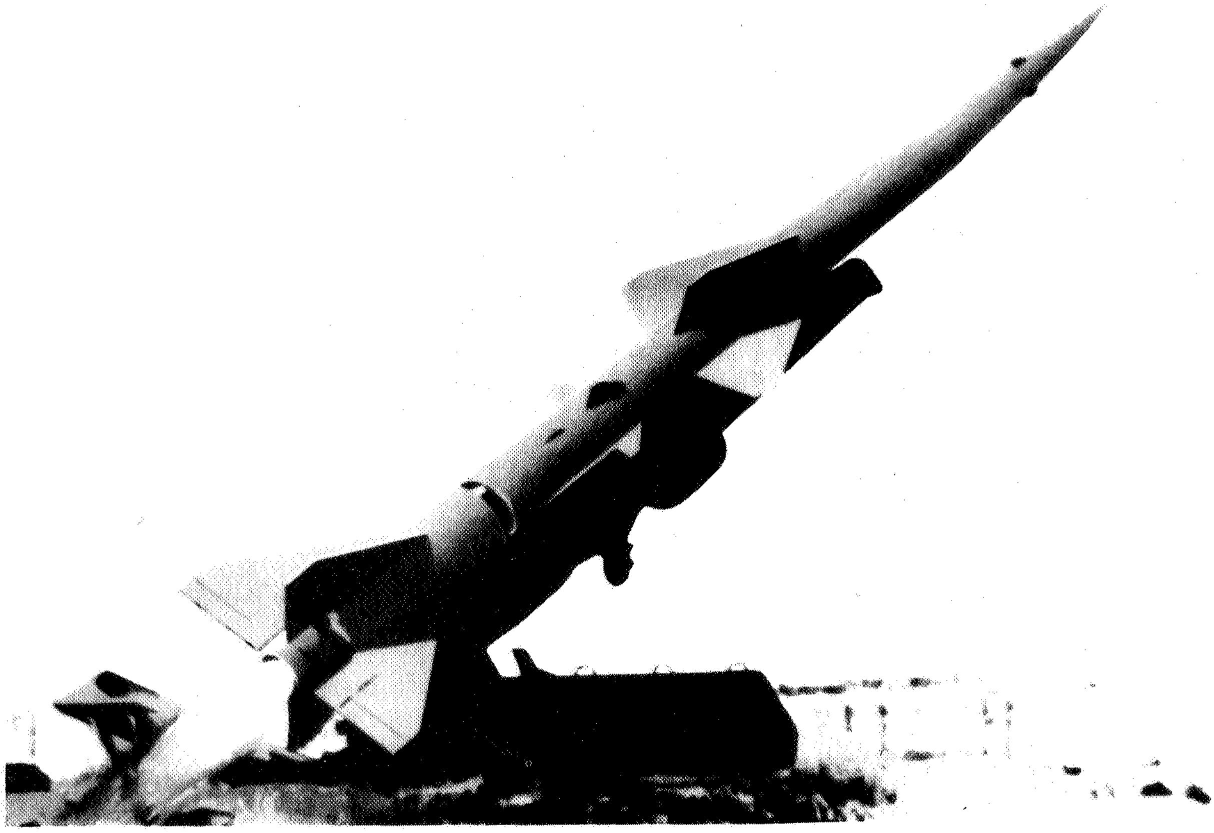
13.2 THREAT ANTIAIRCRAFT WEAPONS

Threat forces have a complete air defense system that integrates the complementary capabilities of individual infantry weapons, vehicle-mounted machineguns, antiaircraft guns, and antiaircraft missiles to form a protective screen around and above the ground force. A thorough understanding of the strengths and weaknesses of the weapons which form the screen will enable helicopters to penetrate it.

13.2.1 Antiaircraft Missiles. Antiaircraft missiles form the outer edge of the screen. They are primarily intended to defeat high performance aircraft, but they can and will be used against helicopters that stray into their kill zones (Figures 13-1 thru 13-7).

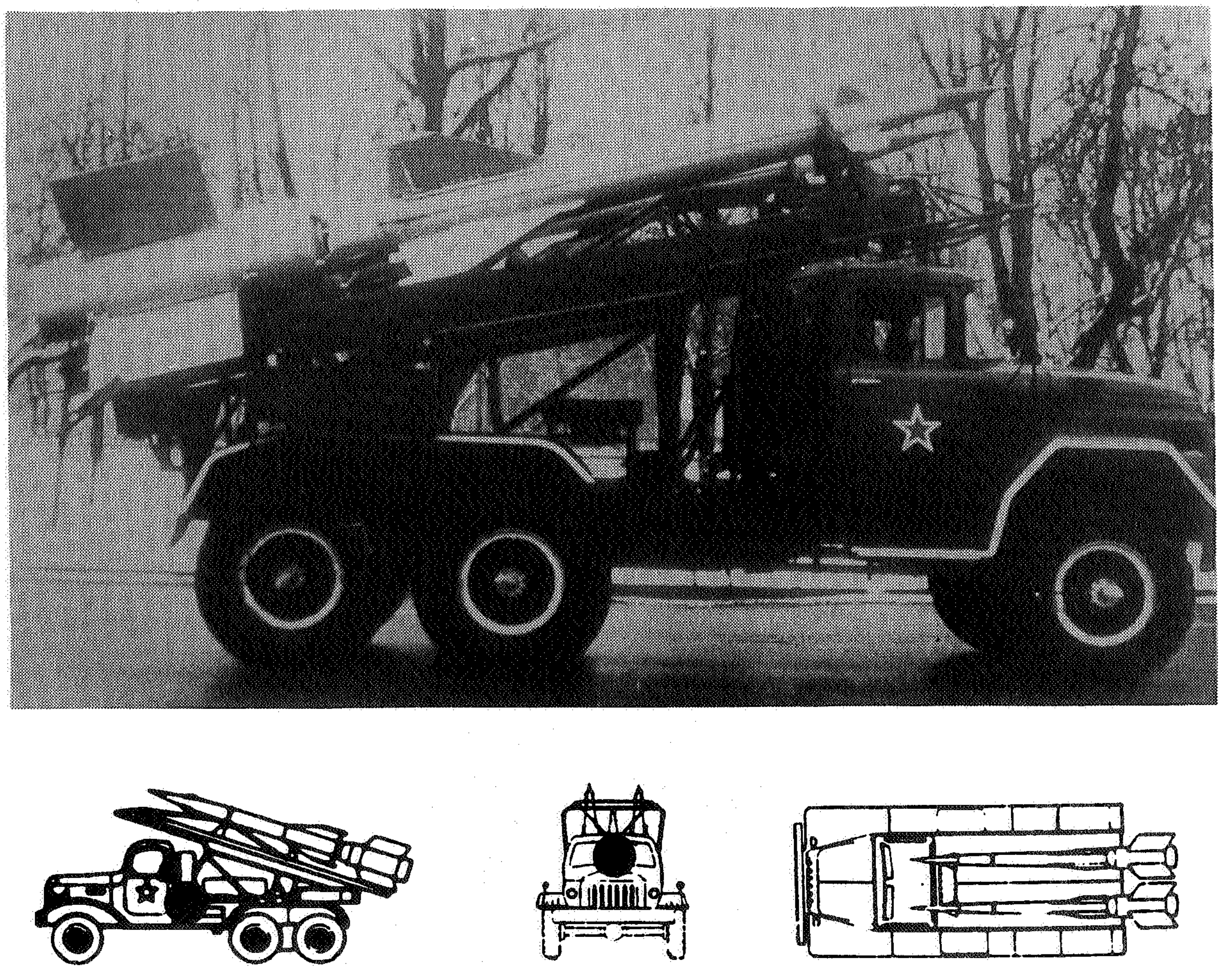
13.2.2 Antiaircraft Guns. Antiaircraft guns complement missile antiaircraft capability by forming the primary low-altitude edge of the screen and the secondary medium altitude defense. They are the greatest threat to the helicopter using terrain flight modes (Figures 13-8 thru 13-12).

13.2.3 Maneuver Force Antiaircraft Weapons. The last line of defense in the



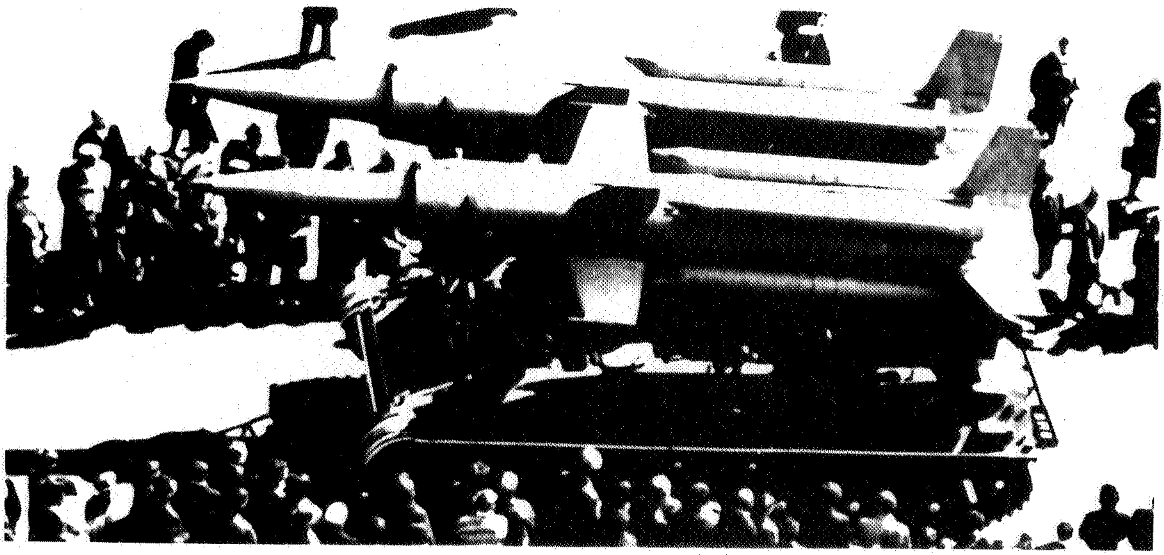
1. RANGE: 45 km/28m
2. ALTITUDE: Medium to high altitude coverage
   Maximum ceiling – 80,000 feet
3. GUIDANCE: Radar (FAN SONG)
4. Not a threat to aircraft operating below 1,000 feet
5. RECOGNITION FEATURES: Two stage, ground-mounted missile; found on single launcher; narrow pencil-like body with groups of 4 stabilization fins; found in groups of 6 in a star-like formation.

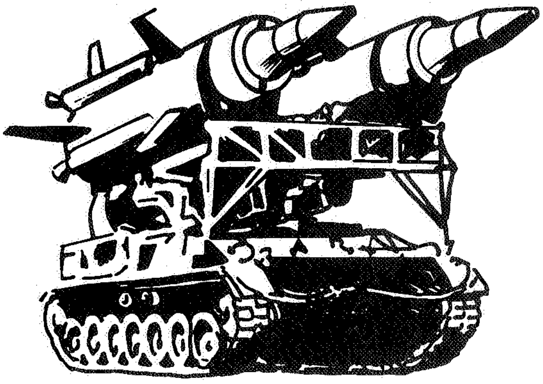
Figure 13-1. SA-2 GUIDELINE SAM



1. RANGE: 6 to 22 km/4 to 14 m
2. ALTITUDE: Medium to low altitude
3. GUIDANCE: Radar (LOW BLOW)
4. Not a threat to aircraft operating below 1,000 feet altitude
5. RECOGNITION FEATURES: Mounted on a six-wheel, heavy utility truck; missiles are two-stage and have front, middle, and rear stabilization fins.

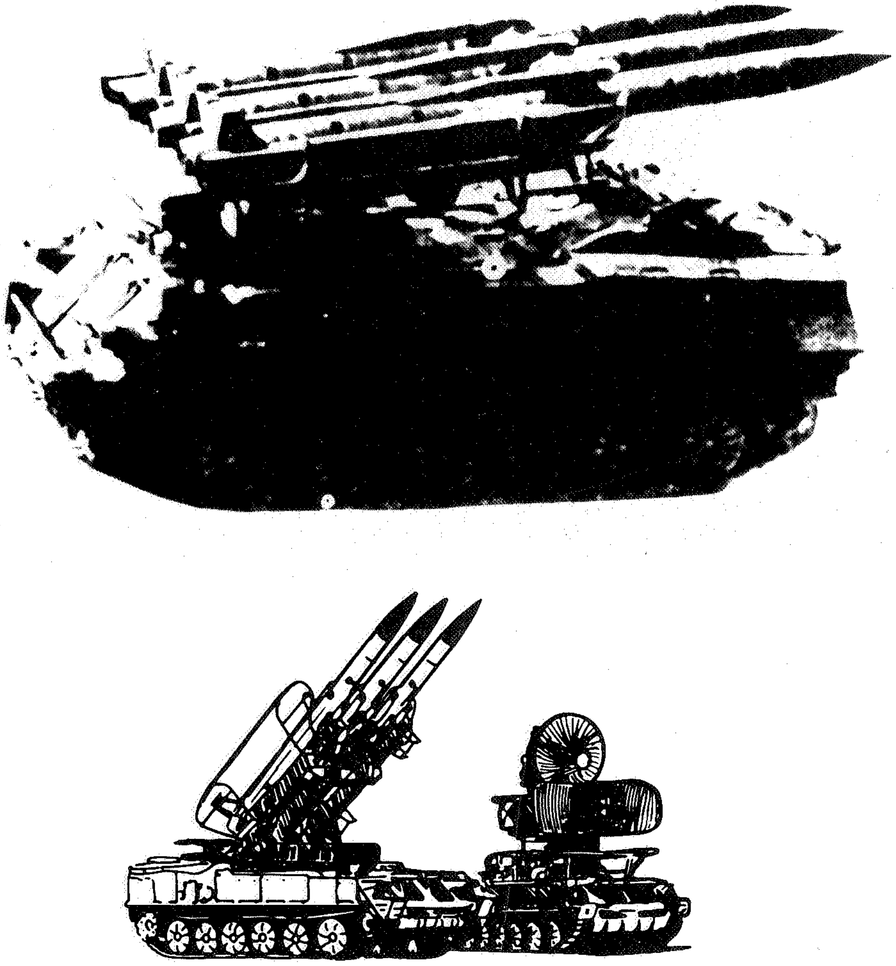
Figure 13-2. SA-3 GOA SAM





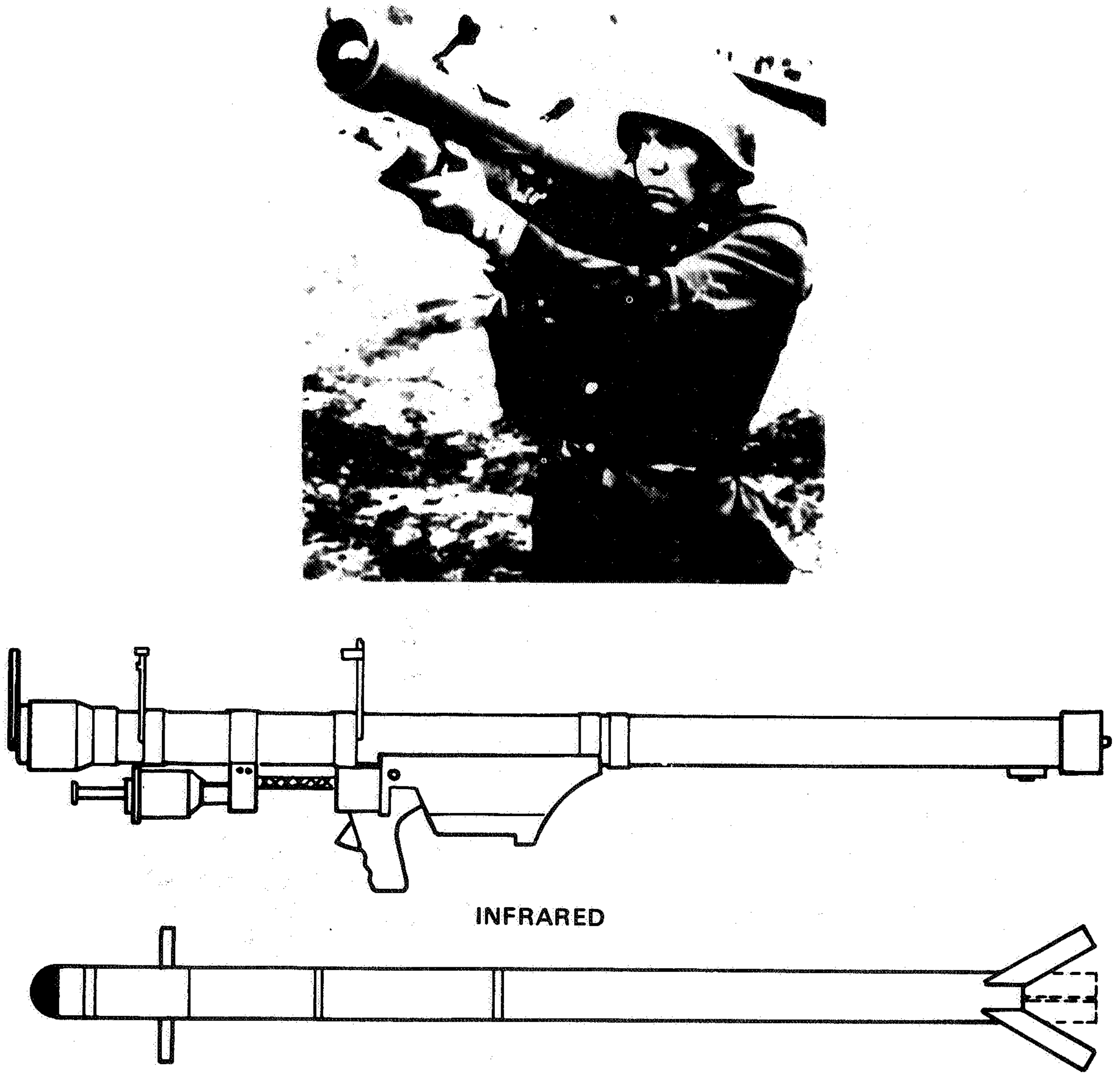
1. RANGE: 70 km/43 m
2. ALTITUDE: medium to high altitude; ceiling 60,000 feet
3. GUIDANCE: Radar (PAT HAND)
4. RECOGNITION FEATURES: Full-tracked, seven-roadwheeled vehicle, carrying two huge two-stage missiles, the points of which overhang the front of the vehicle.

Figure 13-3. SA-4 GANEF SAM



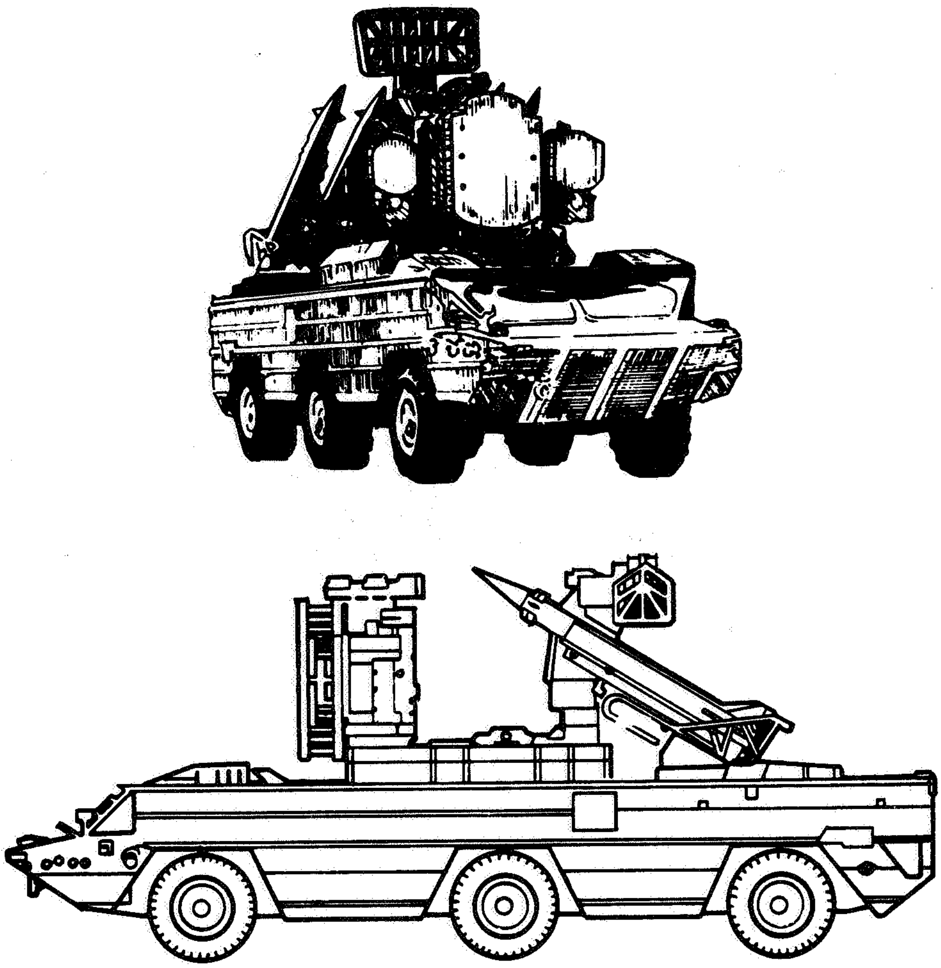
1. RANGE: 35 km/22 m
2. ALTITUDE: Low to medium altitude; ceiling 40,000 feet
3. GUIDANCE: Radar (STRAIGHT FLUSH)
4. RECOGNITION FEATURES: Uses same chassis as ZSU-23-4; instead of turret, mounts a missile rack containing 3 SA-6 missiles.

Figure 13-4. SA-6 GAINFUL SAM



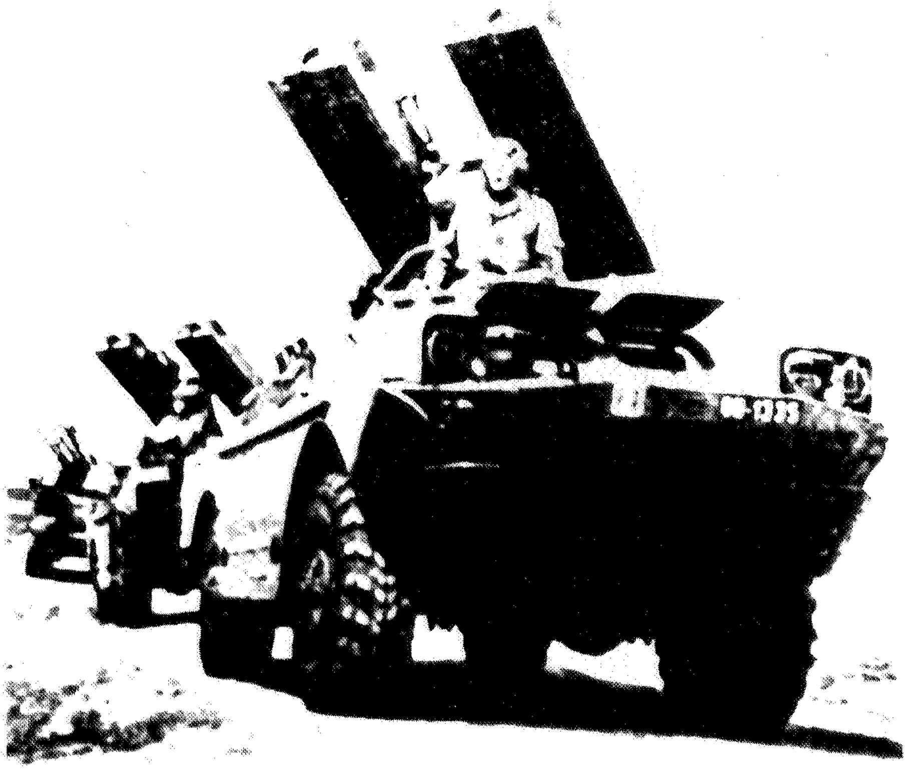
1. RANGE: 3.5 km/2 m
2. ALTITUDE: Min: 50 feet; max: 10,000 feet
3. ACQUISITION: Optical Guidance: IR
4. Man-portable, IR missile
5. RECOGNITION FEATURE: Small, tube-like container with sighting device, similar in appearance to our Redeye.

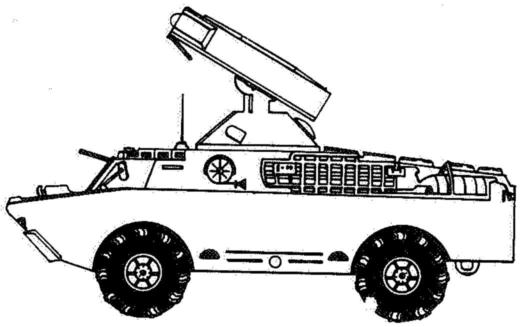
Figure 13-5. SA-7 GRAIL



1. RANGE: 10 to 15 km/6 to 9 m
2. ALTITUDE: 150 to 20,000 feet
3. GUIDANCE: Radar (LAND ROLL), also electro-optical tracker
4. Highly mobile, amphibious SAM system capable of rapid movement with ground forces.
5. RECOGNITION FEATURES: 3-axle amphibious vehicle, carries 4 missiles; radar-mounted towards front of vehicle.

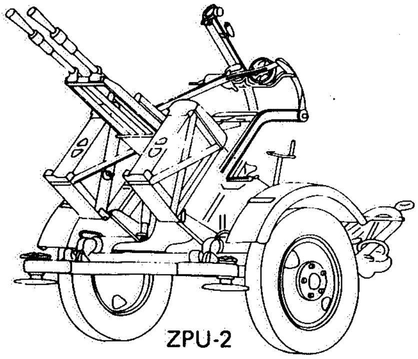
Figure 13-6. SA-8 GECKO

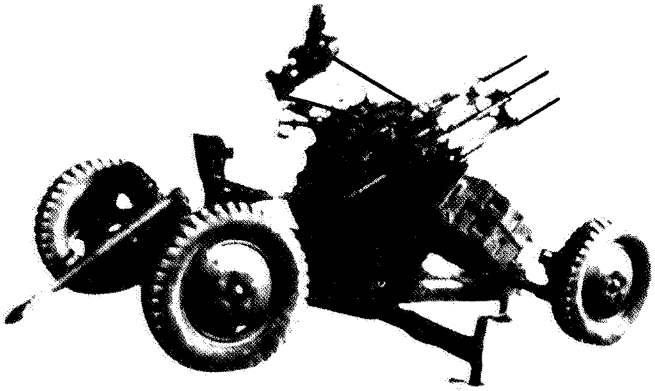


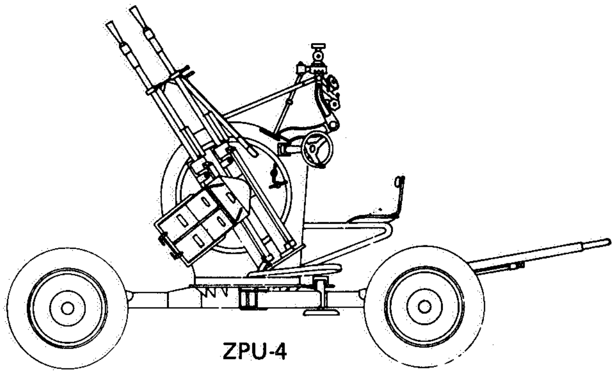


1. RANGE: 7 km/4 m
2. ALTITUDE: Low altitude
3. ACQUISITION: Optical Guidance: IR
4. RECOGNITION FEATURES: Quadruple cannister launchers mounted on BRDM-2
5. IR missile similar to SA-7 but is longer and heavier, with a larger warhead and greater range.
6. Usually employed 1 to 2 km to the rear of ZSU-23-4 in a complementary role.

Figure 13-7. SA-9 GASKIN

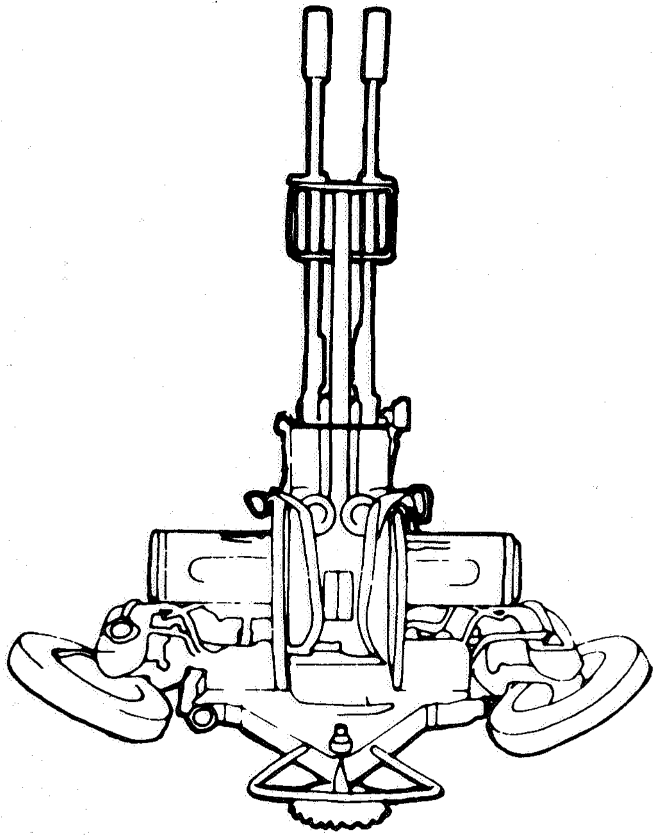






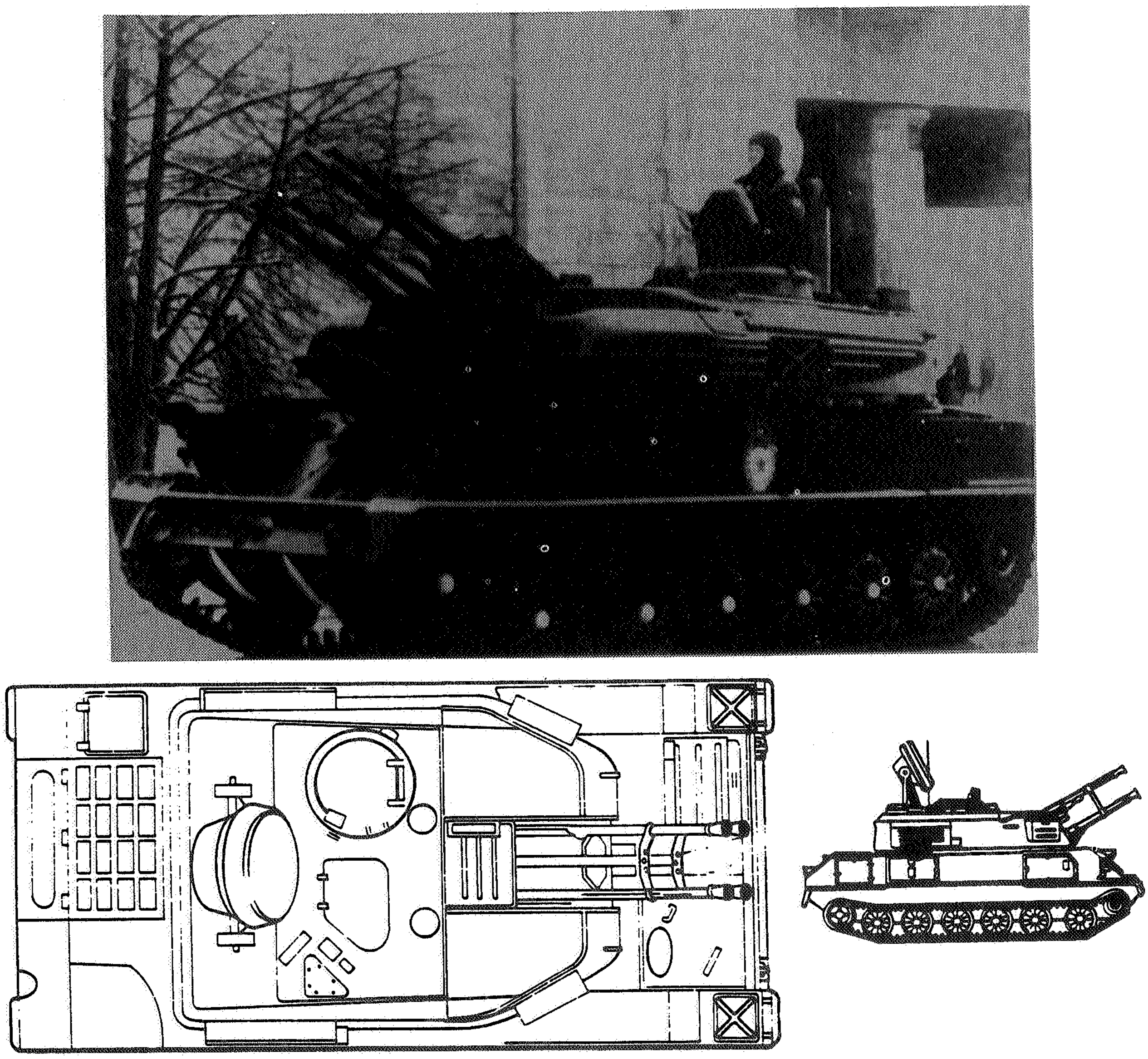
1. RANGE: 1.4 km/.8 m
2. RATE OF FIRE: 550 to 600 rpm per barrel
3. GUIDANCE: Optical
4. VARIANTS: Single barrel: ground mounted,
   vehicle mounted,
   BTR-50/60, BRDM-2
   Double barrel: towed ZPU-2
   Four barrel: towed ZPU-4

Figure 13–8. 14.5–mm Machinegun



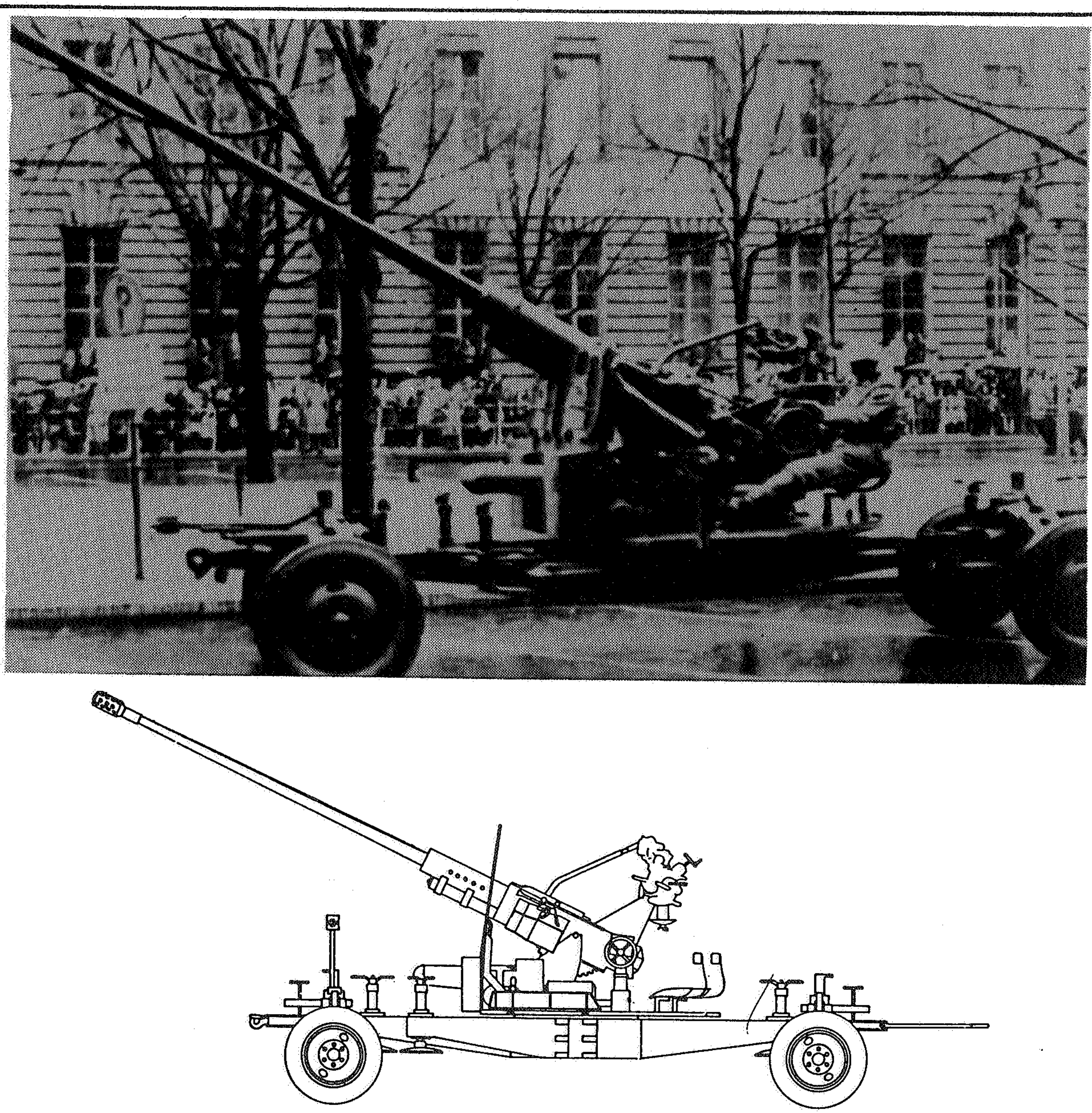
1. RANGE: 2.5 km/1.5 m
2. RATE OF FIRE: 2,000 rpm
3. GUIDANCE: Optical
4. Light towed, automatic AA which is replacing the quad 14.5-mm ZPU-4.

Figure 13-9. ZU-23-2 Towed Antiaircraft Gun



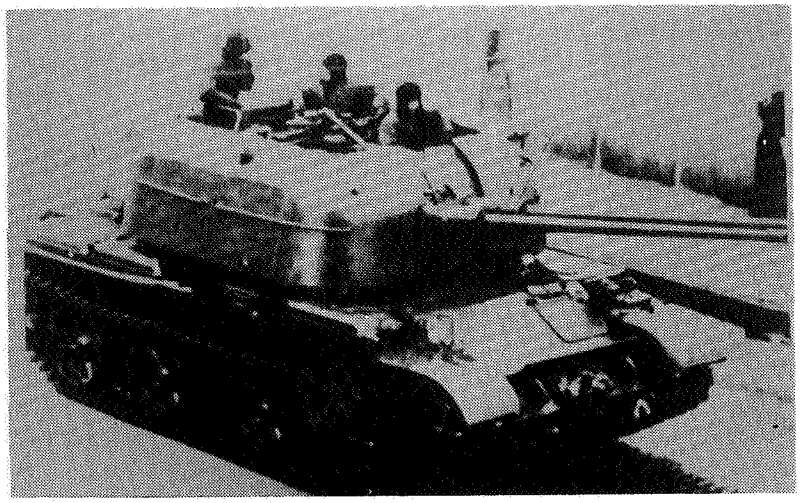
1. RANGE: Radar: 3 km/1.9 m
   Optical: 2.5 km/1.5 m
2. RATE OF FIRE: 1,000 rpm per barrel
3. GUIDANCE: Radar (GUNFISH) and optical
4. RECOGNITION FEATURES: Full-tracked, six-roadwheeled vehicle; high, boxlike hull with a rectangular turret centered over the third roadwheel; turret mounts four 23-mm automatic AA guns.

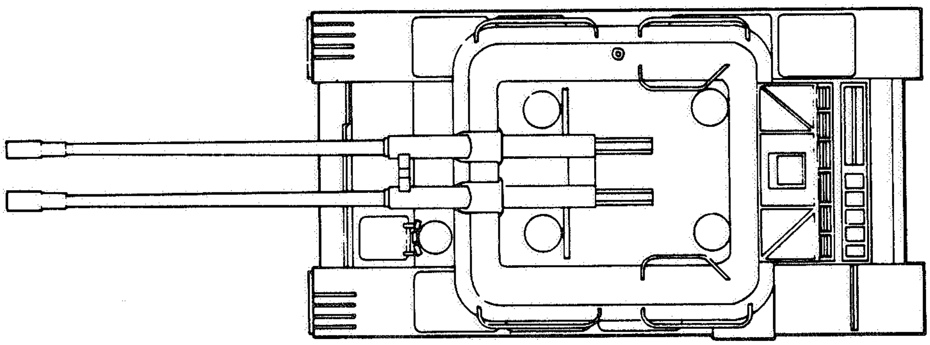
Figure 13-10. ZSU-23-4 SHILKA Antiaircraft Gun



1. RANGE: Radar: 6 km/3.7 m
   Optical: 4 km/2.5 m
2. RATE OF FIRE: 105 to 120 rpm
3. GUIDANCE: Radar (FIRE CAN) and optical
4. RECOGNITION FEATURES: Four-wheeled mount contains elevation and traversing devices, along with one 57-mm automatic cannon.

Figure 13-11. S-60 Antiaircraft Gun





1. RANGE: 4 km/2.5 m
2. RATE OF FIRE: 70 rpm per barrel
3. GUIDANCE: Optical
4. RECOGNITION FEATURES: Full-tracked; four-roadwheeled; flat hull; mounting a bowl-type turret with two 57-mm AA cannons.

Figure 13-12. ZSU-57-2 Antiaircraft Gun

antiaircraft screen consists of maneuver force weapons: vehicle-mounted machineguns, individual soldier's weapons, and the man-portable SA-7/14, SA-8, and SA-9/13 vehicle-mounted IR missiles. Refer to Figures 13-5, 13-6, 13-7, 13-13, and 13-14. For more information concerning the SA-13 and the SA-14, refer to NWP 55-9-ASH, Volume II.

13.2.4 Strengths of Threat Antiaircraft Weapons. Antiaircraft missiles form a lethal screen above the threat ground force at the ranges and altitudes portrayed in Figure 13-15. The low-altitude gap in the missile screen is filled by antiaircraft guns and ground maneuver force weapons at the ranges and altitudes portrayed in Figure 13-16.

Although threat radar-controlled weapons cannot lock on and engage helicopter flights accurately outside of the kill zone, they may be able to track those which needlessly expose themselves. A ground force could then maneuver to ambush a helicopter flight or adjust artillery on an expected location.

The basic strength of maneuver force weapons is the man behind the weapon. He knows he is being hunted and will employ every means to deter the hunter. To increase kill probability, he will coordinate the use of multiple antiaircraft weapons on a target.

13.2.5 Weaknesses of Threat Antiaircraft Weapons

1. They are limited to line of sight.

2. They are susceptible to suppressive fire; armored varieties are somewhat protected, but their guidance systems are vulnerable and some are exposed on top.

3. Those that depend totally or partially on optical target acquisition and tracking are susceptible to obscuration with smoke.

4. They must be deployed in relatively open terrain to take full advantage of their capabilities.

5. They can be destroyed by direct fire.

6. Radar systems are susceptible to electronic countermeasures.

7. Their capabilities are significantly reduced while on the move.

13.3 THREAT SOLDIER

The threat soldier is first a *field soldier*. He spends most of each training day learning to live and fight in the field. For him, theory is no substitute for practice in field living and operations.

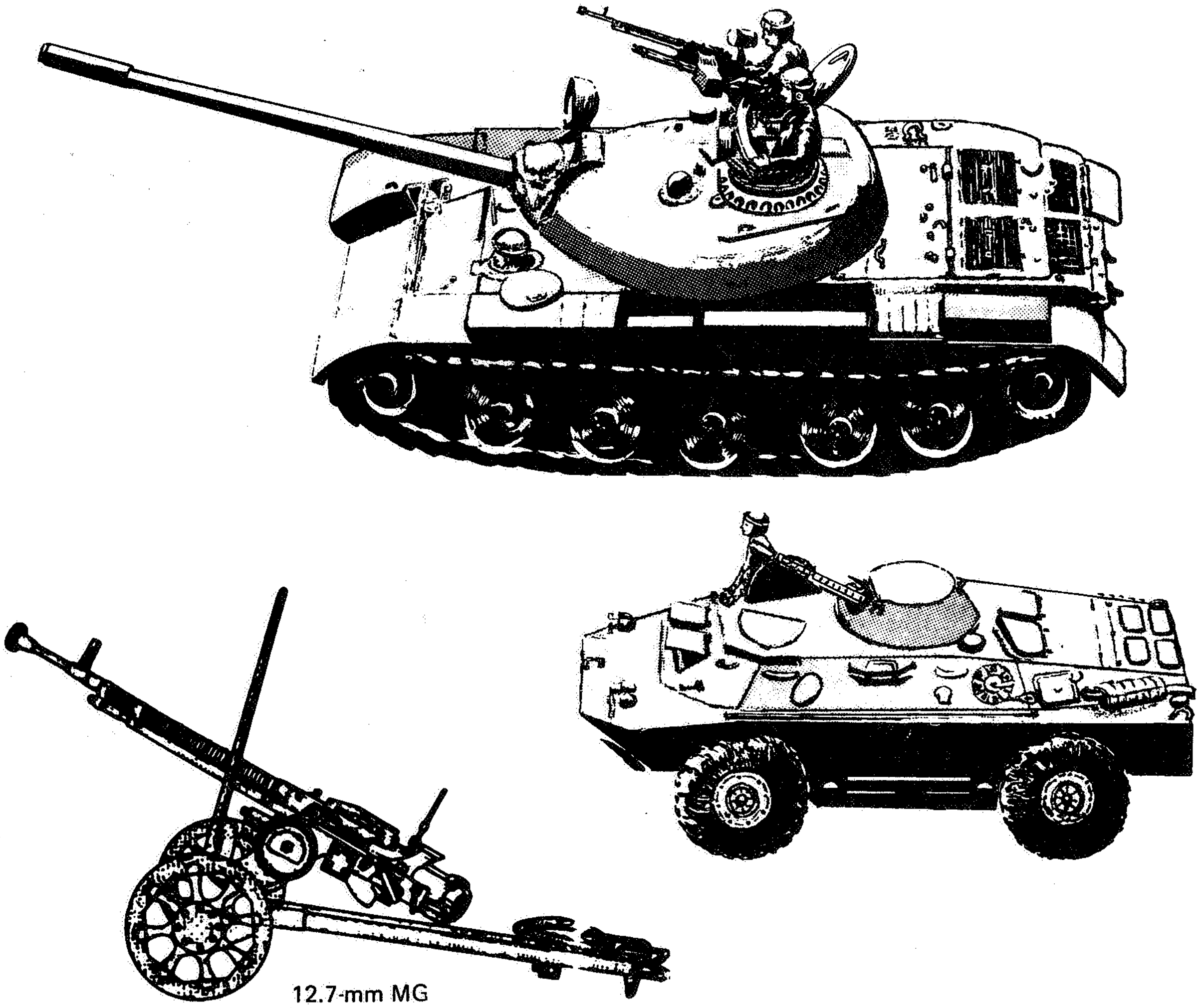
Threat soldiers are often highly motivated, sometimes through fear of their leaders or political commanders, but often because of thorough and effective political indoctrination. The threat soldier in battle is tough and callous — a good fighter. He is indifferent to hardship, especially when he believes he is righteously defending his country against aggression.

13.4 THREAT ARMORED VEHICLES

Threat armored vehicles are formidable weapon systems with extremely lethal capabilities. However, like all other armored vehicles, they can be suppressed and destroyed. The use of smoke is an excellent obscuration technique, preventing threat weapons systems from visually acquiring targets. The enemy's ability to acquire targets is also degraded by artillery and small arms fire which makes threat armor operate with closed hatches.

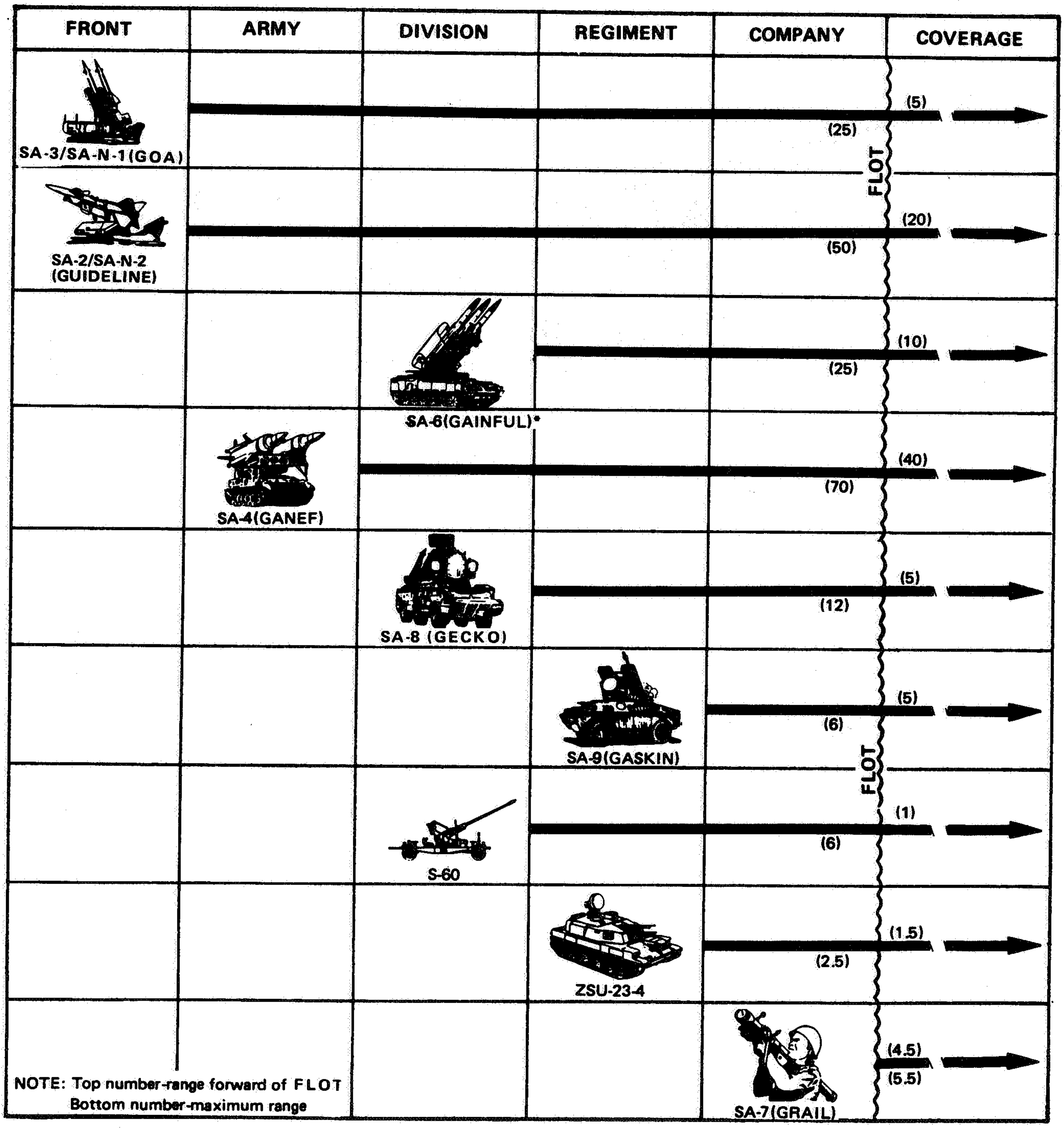
13.5 THREAT ARTILLERY

Employment of massive artillery fire has always characterized threat force doctrine. In line with threat emphasis on offensive striking power as the primary battlefield tactic, artillery is used to annihilate defensive positions to open the way for their rapid-moving armored and motorized units. Threat leaders require that their artillery pieces function as direct antiarmor; therefore, the threat artillery pieces have a lower trajectory than ours. As a result, it is more difficult for enemy artillery to hit terrain-masked positions than it is for our



1. RANGE: 1 km/.6 m
2. ALTITUDE: Low
3. GUIDANCE: Optical
4. Platoon level; ground or vehicle mounted.
5. Most armored vehicles mount either the 12.7-mm or 14.5-mm MG.

Figure 13-13. Ground or Vehicle-Mounted 12.7-mm Machineguns



NOTE: Top number-range forward of FLOT
Bottom number-maximum range

All ranges in Kilometers

Figure 13-14. Air Defense Weapons Mixture

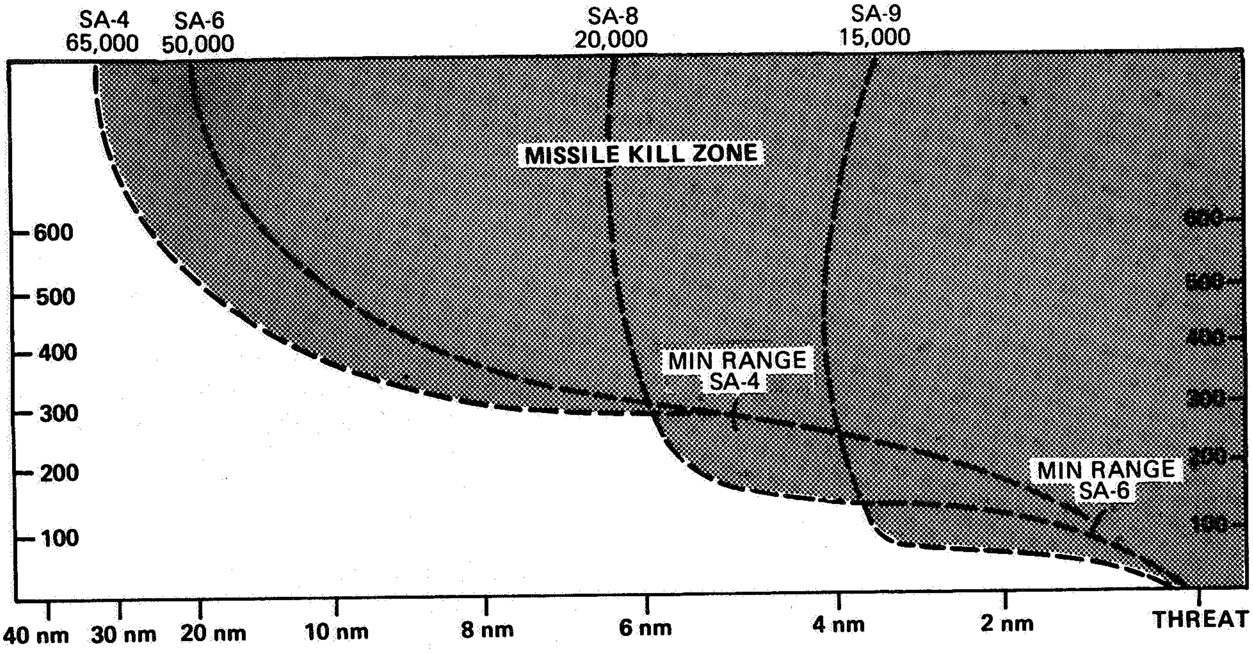


Figure 13-15. Forward Edge of Air Defense Screen

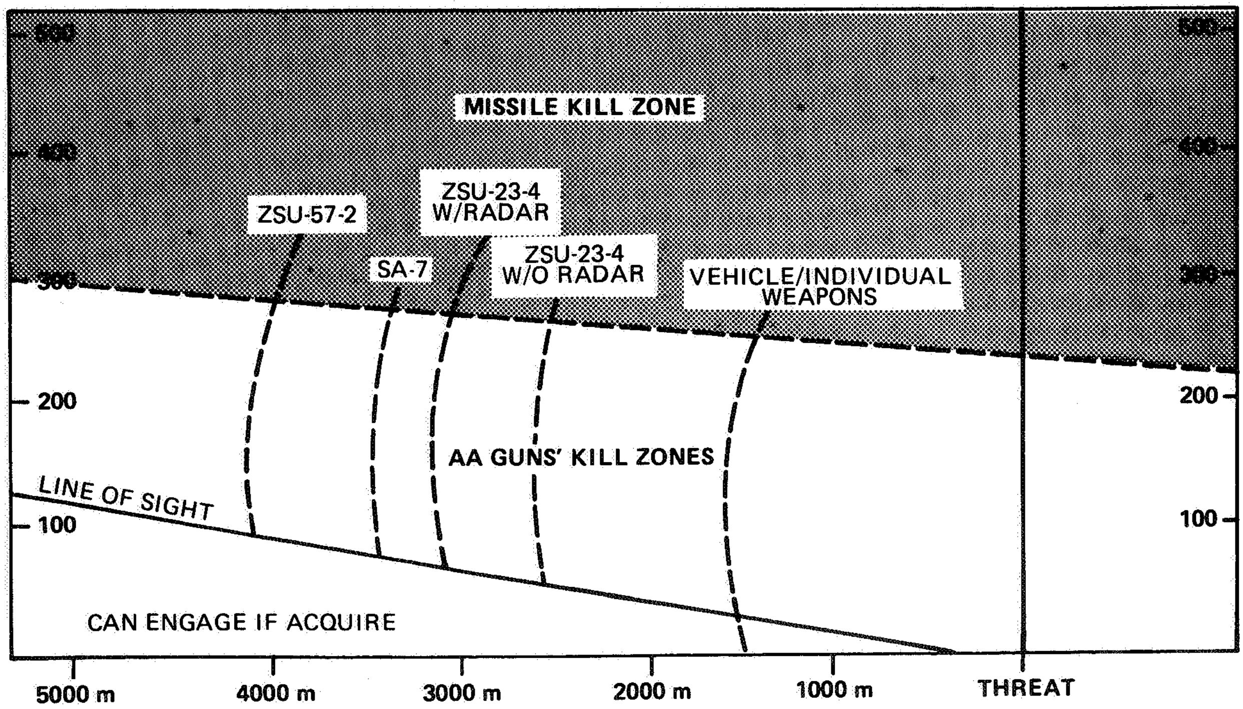


Figure 13-16. Low-Altitude Air Defense Screen

artillery. Threat artillery often will be positioned to place direct antitank fires on possible armor approaches as well as to provide indirect fire.

The most common field pieces are the 122-mm and 152-mm towed and self-propelled howitzers. Threat forces commonly use the multiple rocket launcher for area coverage. Although available in many sizes, the most common is the 122-mm truck-mounted launcher. Threat force mortars have the same employment capabilities as ours and are similar in design. The most common, the 120 mm, is the standard mortar for the motorized rifle battalion.

13.6 THREAT JET AIRCRAFT

Threat tactical air support is controlled by ground force commanders who employ it first to gain air superiority, and then to engage targets beyond artillery range, reinforce artillery fire, and attack targets of opportunity. Threat artillery preparation usually includes coordinated tactical air sorties. Threat air support provides a ground commander with a long-range extension of his artillery near an enemy's rear area (Figure 13-17 (Sheets 1 thru 10)).

13.7 THREAT HELICOPTERS

Threat force doctrine concerning the use of helicopters is currently expanding. It is anticipated that threat forces will employ cargo, lift, and attack helicopters in the future in greater number and for a wide variety of missions. Threat force assets include large heavy-lift helicopters for moving supplies, some troop-carrying helicopters for airmobile operations, and some attack helicopters.

Figures 13-18 thru 13-26 provide information on threat force helicopters. HIND-A mounts 57-mm rocket pods, a 23-mm cannon in the nose, and two dual antitank missile launchers. It carries 8 to 12 troops or, without troops, additional fuel and ordnance. HIND-D is a slimmed down version which carries no additional troops. It is known to be capable of firing missiles while hovering in out-of-ground effect operation. Three threat force utility helicopters — HIP, HOUND, and HOPLITE — have been observed with armament configurations which included machineguns, rockets, and antitank missiles.

13.8 THREAT SURFACE VESSELS

Refer to Figure 13-27.

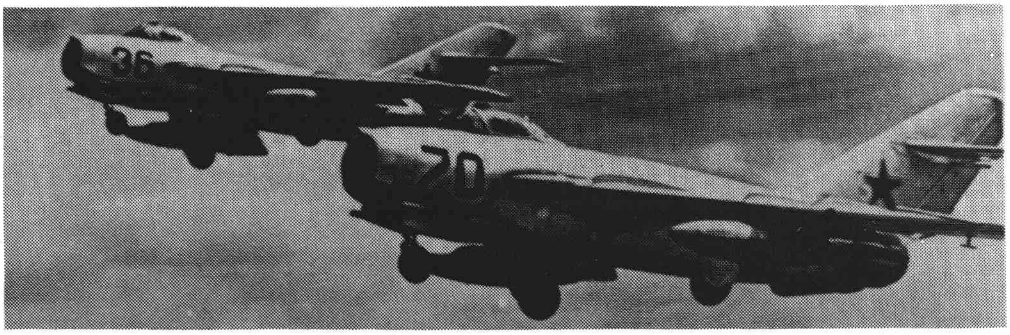
13.9 THREAT WEAPONS SYSTEMS

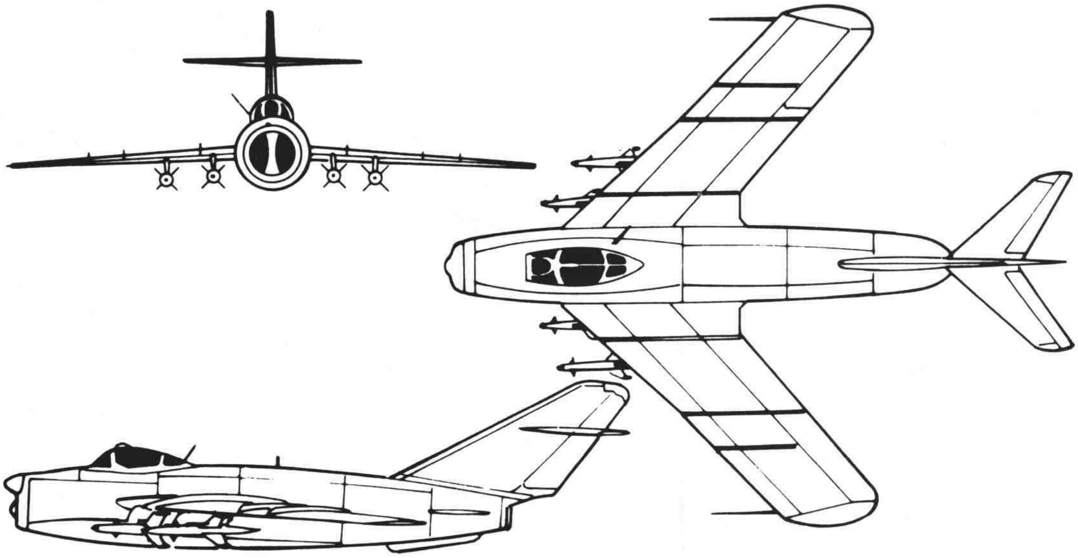
Figure 13-28 provides information on air defense weapons systems distribution in a typical threat army. Figure 13-29 provides information on weapons in a typical threat tank battalion, reinforced by one motorized rifle company. Figure 13-30 provides this information for a typical threat motorized rifle battalion, reinforced by one tank company.

Threat forces can be expected to use the basic principles of mobility and mix.

Except for individual infantry weapons, all other threat weapons are mounted on wheels or tracks. Anything that is too heavy to handle easily has been placed on a prime mover to provide mobility. Forward area gun/missile units are able to keep up with and maintain air defense coverage for the maneuver force. Highly mobile air defense systems follow directly behind the battle line of tanks ready to fire at helicopters. These are capable of firing at low-flying aircraft either while moving or during brief halts. Mobility of modern tactical radars is compatible with that of ground forces. A pilot should never expect air defense systems to remain in fixed positions. A gun or missile site, once located either by reconnaissance or engagement, will move. Any attempt to destroy the weapon must be made as soon as it is located.

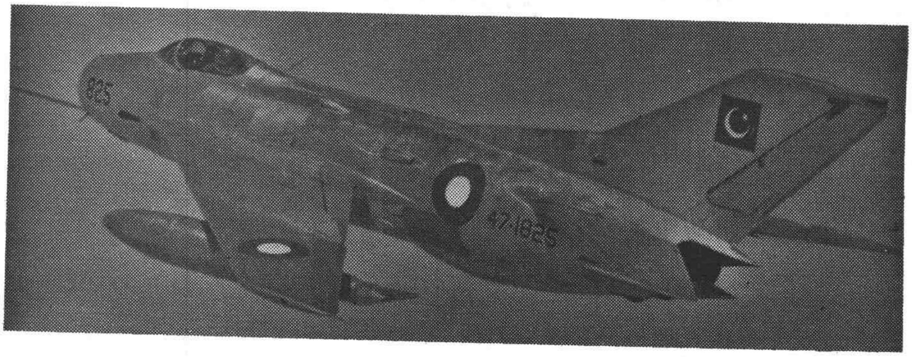
Various types of weapons are integrated to complement the air defense weapons system. These threat weapons overlap to provide complete coverage of the battlefield. The capabilities of one system offset the limitations of another so that aircraft cannot defeat in detail any particular weapon system. Forward area guns are employed in combination with short-range air defense missiles to protect critical assets. The long-range and medium-range radar-directed systems complement forward

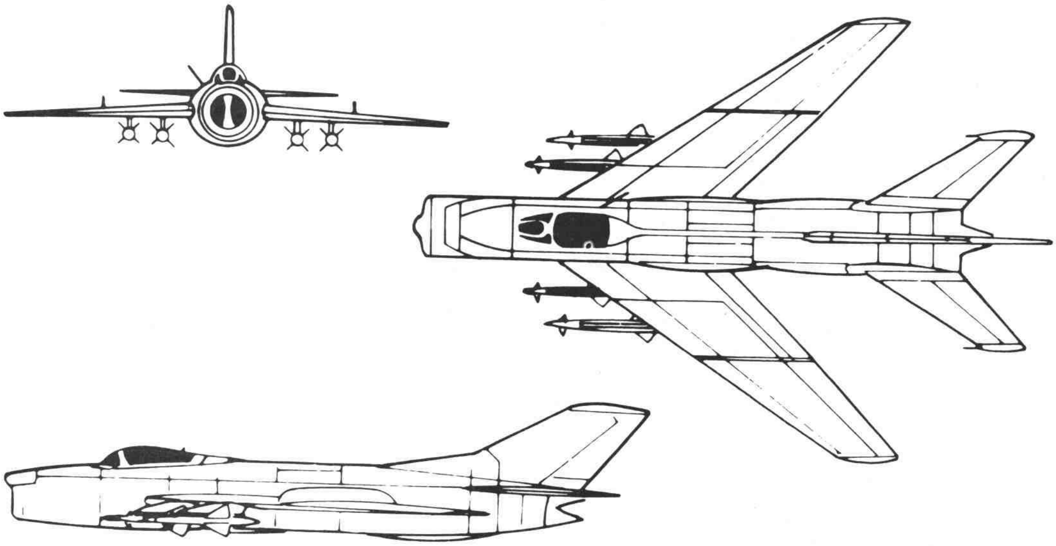




MiG-17 FRESCO
SPEED: 675 kts
RANGE: 579 km/360 m; w/external tanks – 959 km/590 m
WINGSPAN: 10 meters/33 feet
LENGTH: 11 meters/36 feet
ARMAMENT: Three 23-mm cannons; two 57-mm rocket pods (16 each) or two 550-lb bombs or air-to-air missiles.
COMBAT ROLE: Fighter interceptor; ground attack; reconnaissance; advanced trainer.

Figure 13–17. Threat Force Fighter Aircraft (Sheet 1 of 10)





MiG-19 FARMER

SPEED: 600+ kts

RANGE: 587 km/360 m; w/external tank – 990 km/610 m

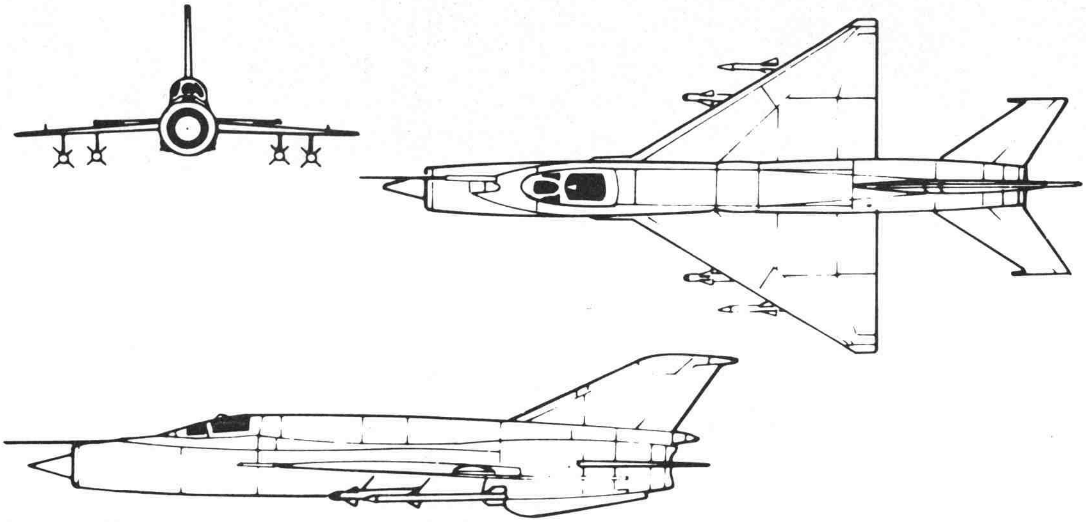
WINGSPAN: 9 meters/30 feet

LENGTH: 12 meters/39 feet

ARMAMENT: Three 30-mm cannons; four 57-mm rocket pods; two Atoll air-to-air missiles or two 550-lb bombs.

COMBAT ROLE: Fighter interceptor; ground attack; reconnaissance.

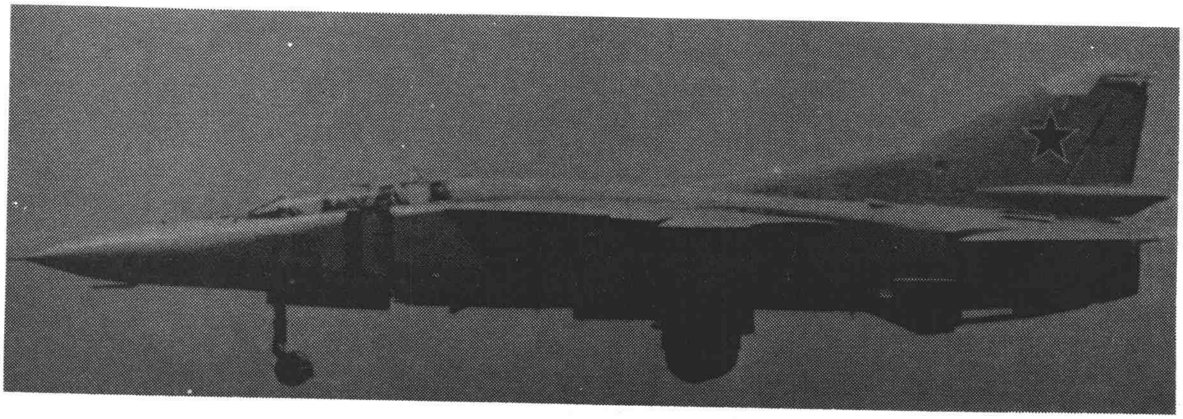
Figure 13–17. Threat Force Fighter Aircraft (Sheet 2 of 10)

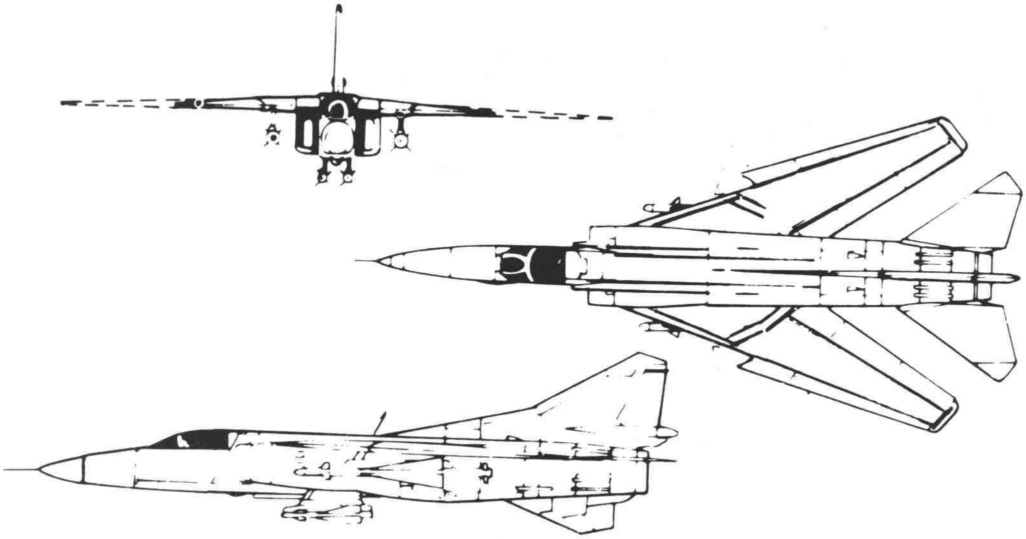


MiG-21 FISHBED

SPEED: 1215 kts
RANGE: 650 km/403 m; w/external tanks – 921 km/570 m
WINGSPAN: 7 meters/23 feet
LENGTH: 16 meters/52 feet
ARMAMENT: One 23-mm cannon; four Atoll air-to-air missiles; four 57-mm rocket pods (16 each) or two 550-lb bombs.
COMBAT ROLE: All weather fighter, ground attack, or reconnaissance.

Figure 13–17. Threat Force Fighter Aircraft (Sheet 3 of 10)

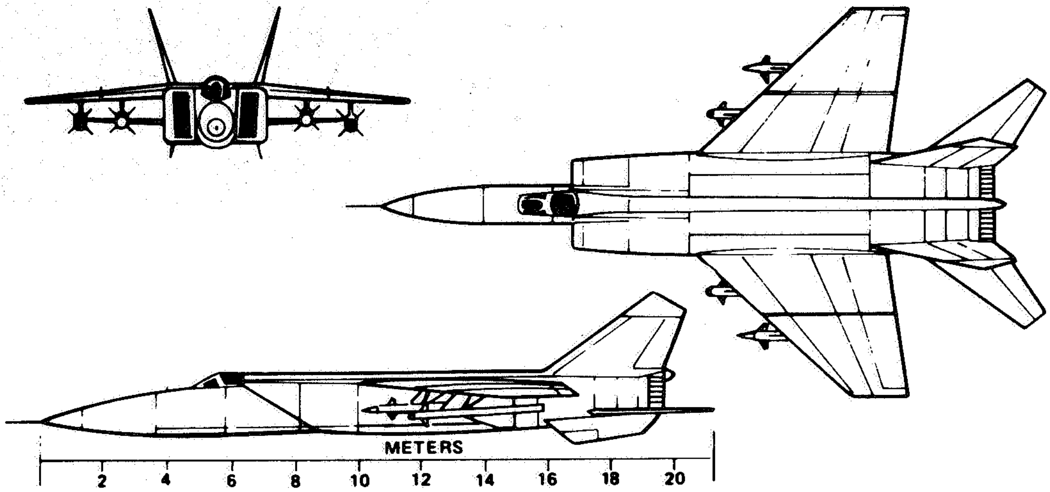




MiG-23 FLOGGER

SPEED: Mach 2.3; Mach 1.1 at sea level
RANGE: 1,708 km/1,057 m
WINGSPAN: 14.3 meters/47 feet; swept 8.2 meters/27 feet
LENGTH: 16.8 meters/55 feet
ARMAMENT: One 23-mm cannon (twin barrel); two 550-lb bombs.
COMBAT ROLE: Fighter, interceptor, ground attack.

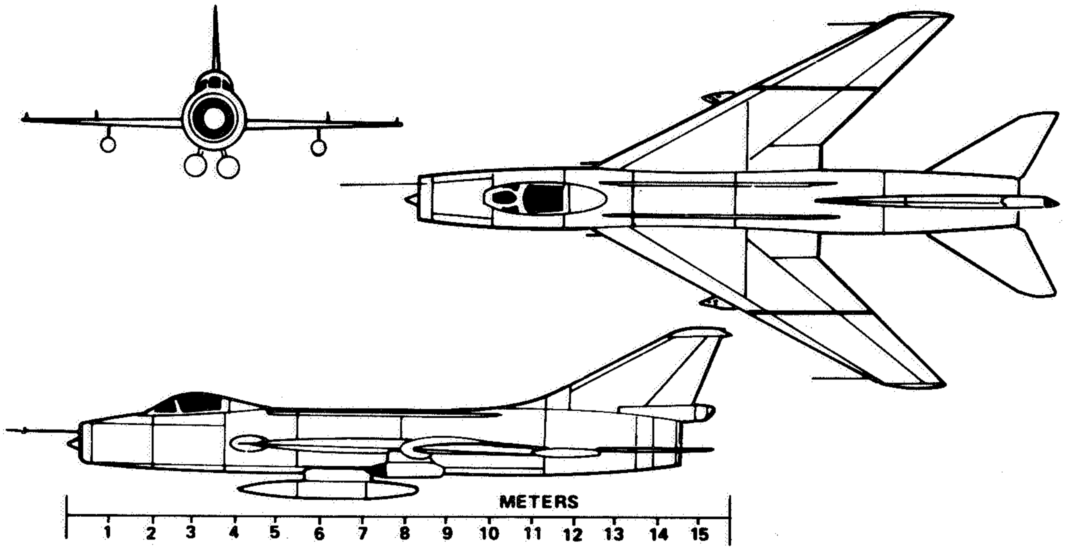
Figure 13-17. Threat Force Fighter Aircraft (Sheet 4 of 10)



MiG-25 FOXBAT

SPEED: 1,830 kts
RANGE: 2,092 km/1,297 m
WINGSPAN: 14 meters/46 feet
LENGTH: 22.3 meters/73 feet
ARMAMENT: Classified
COMBAT ROLE: Interceptor, reconnaissance

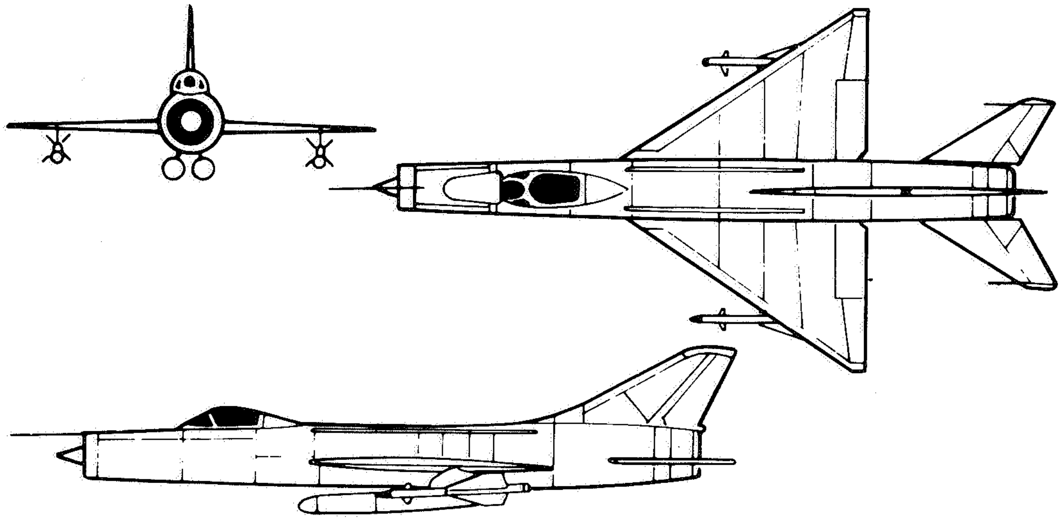
Figure 13-17. Threat Force Fighter Aircraft (Sheet 5 of 10)



SU-7 FITTER A

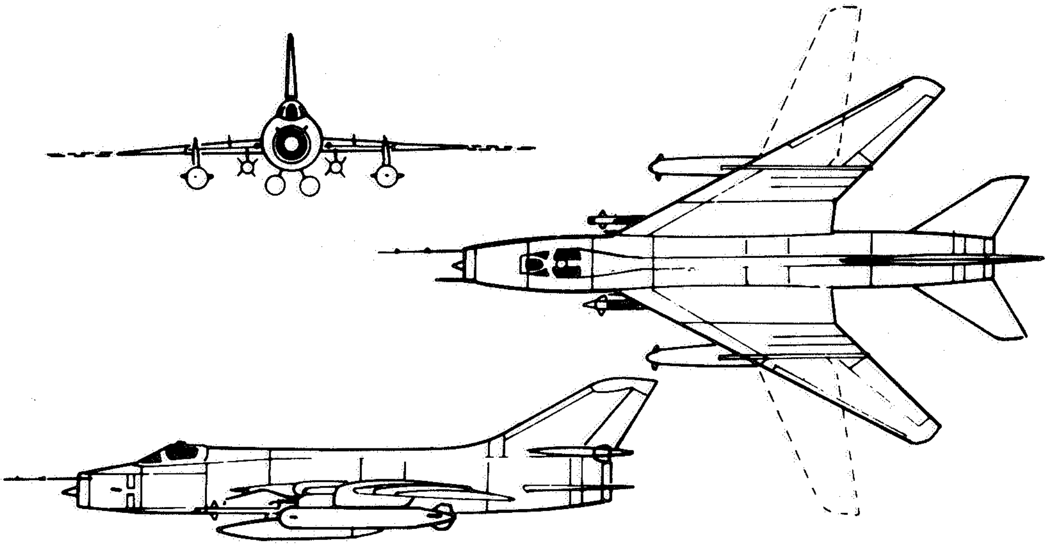
SPEED: Mach 1.5/460 kts (sea level)
RANGE: 640 km/369 m to 960 km/595 m
WINGSPAN: 9 meters/29 feet
LENGTH: 17 meters /56 feet
ARMAMENT: Two 30-mm cannons; two 1,650-lb bombs or two 1,100-lb bombs or rocket pods.
COMBAT ROLE: Close air support.

Figure 13-17. Threat Force Fighter Aircraft (Sheet 6 of 10)



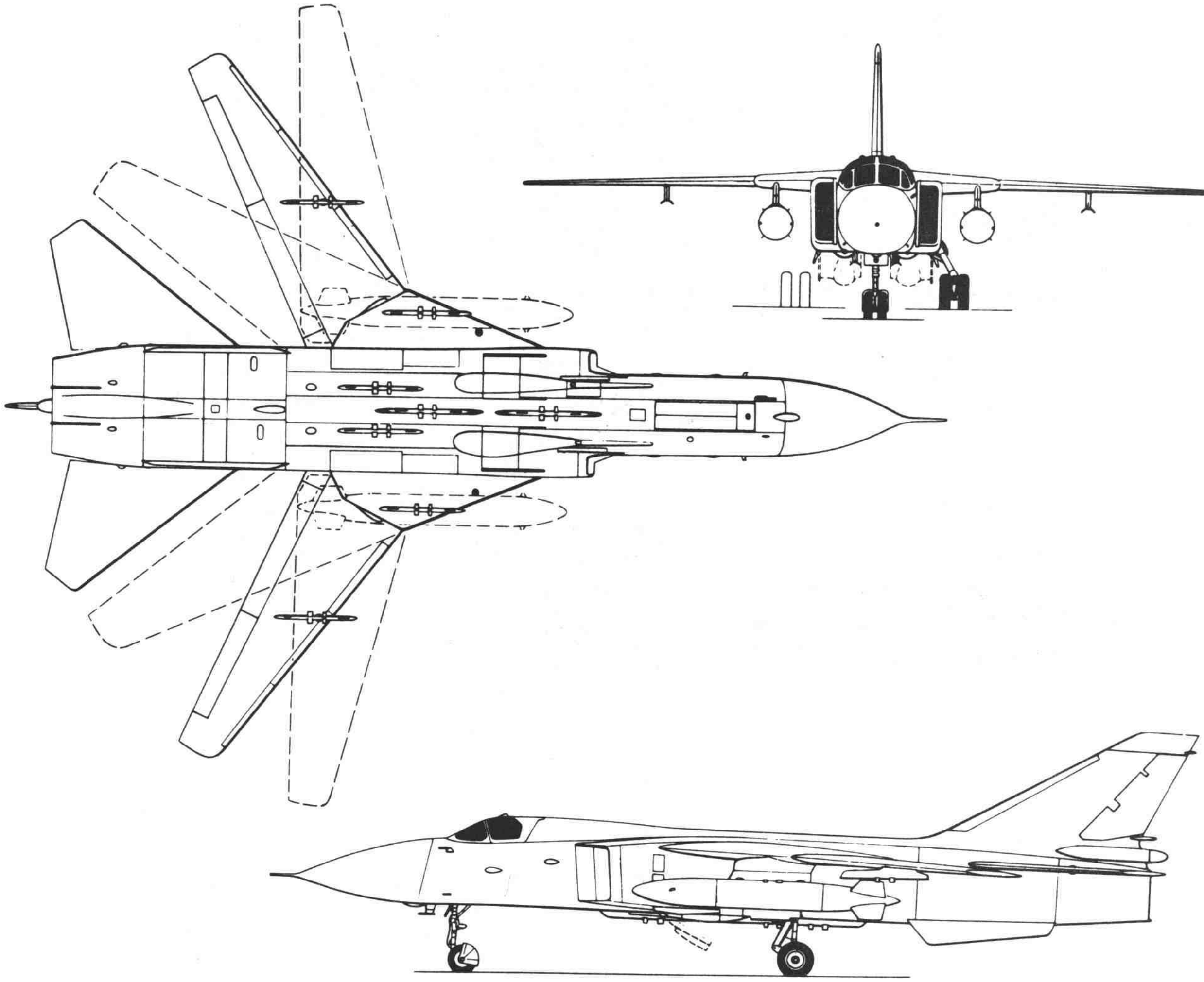
SU-9/11 FISHPOT
WING SPAN: 26 ft
LENGTH: 56 ft
MAX SPEED: (High) 1,033 knots
MAX RANGE: 700 miles
ARMAMENT: SU-9 – four AA-1 ALKALI
SU-11 – two AA-3 ANAB, one IR, and one radar

Figure 13–17. Threat Force Fighter Aircraft (Sheet 7 of 10)



SU-17 FITTER C
WINGSPAN: 41 ft; swept 29 ft
LENGTH: 56 ft
MAX LEVEL SPEED: 650 kts (sea level)
MAX RANGE: 465 miles
ARMAMENT: Two 30-mm cannons, plus rockets
VARIANT: SU-20 (Export)

Figure 13–17. Threat Force Fighter Aircraft (Sheet 8 of 10)



SU-24 FENCER

SPEED: Mach 2+

RANGE: 1,800 km/1,115 m

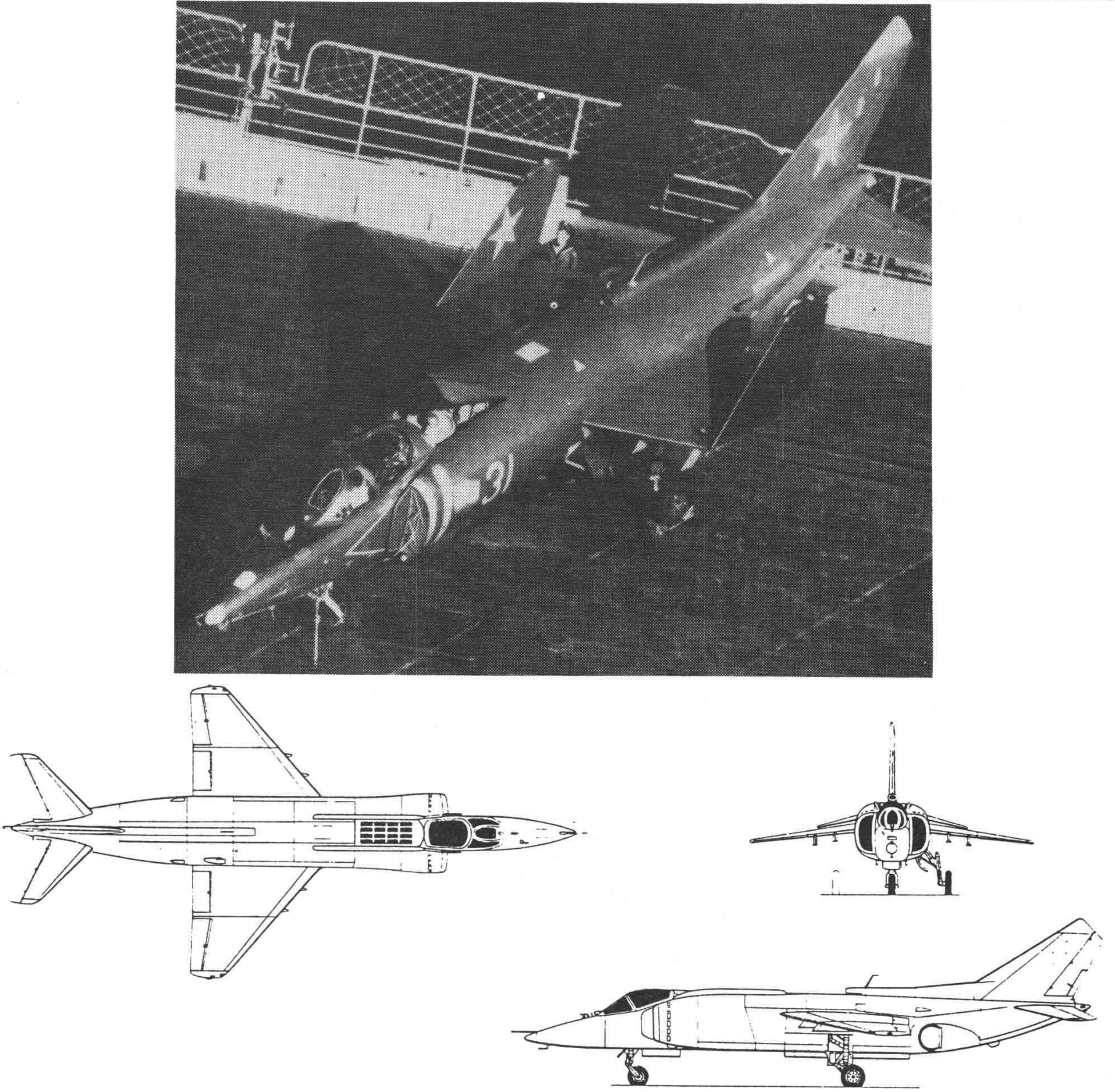
WINGSPAN: 20 meters/66 feet; swept: 12 meters/39 feet

LENGTH: 24 meters/79 feet

ARMAMENT: One 23-mm cannon (twin barrel), six weapons pylons for guided or unguided air-to-surface weapons.

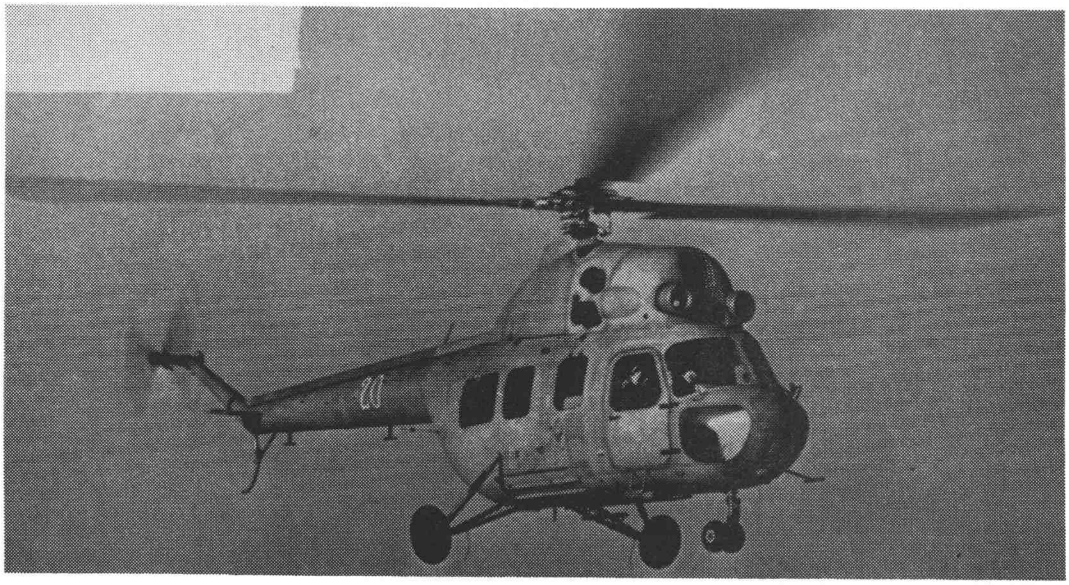
COMBAT ROLE: Fighter, bomber.

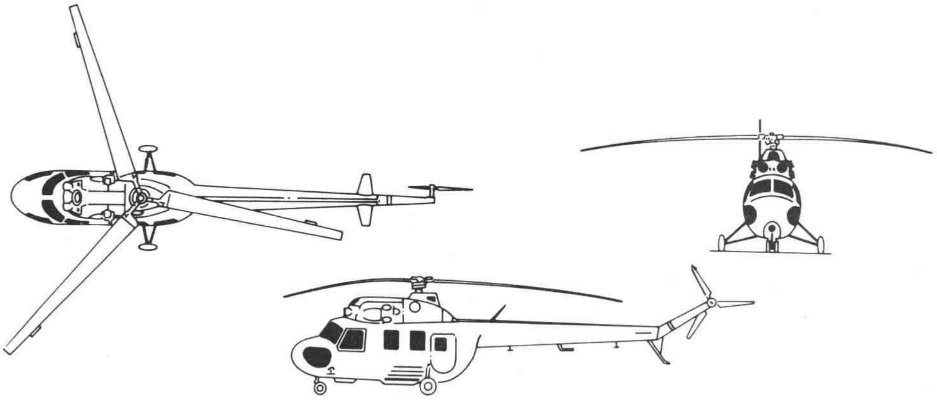
Figure 13-17. Threat Force Fighter Aircraft (Sheet 9 of 10)



YAK-36 FORGER (V/STOL)
WING SPAN: 27 feet
LENGTH: 53 feet
MAX SPEED: 600 kts
MAX RANGE: 200 miles
ARMAMENT: May carry external gun or two AA-2 Atolls

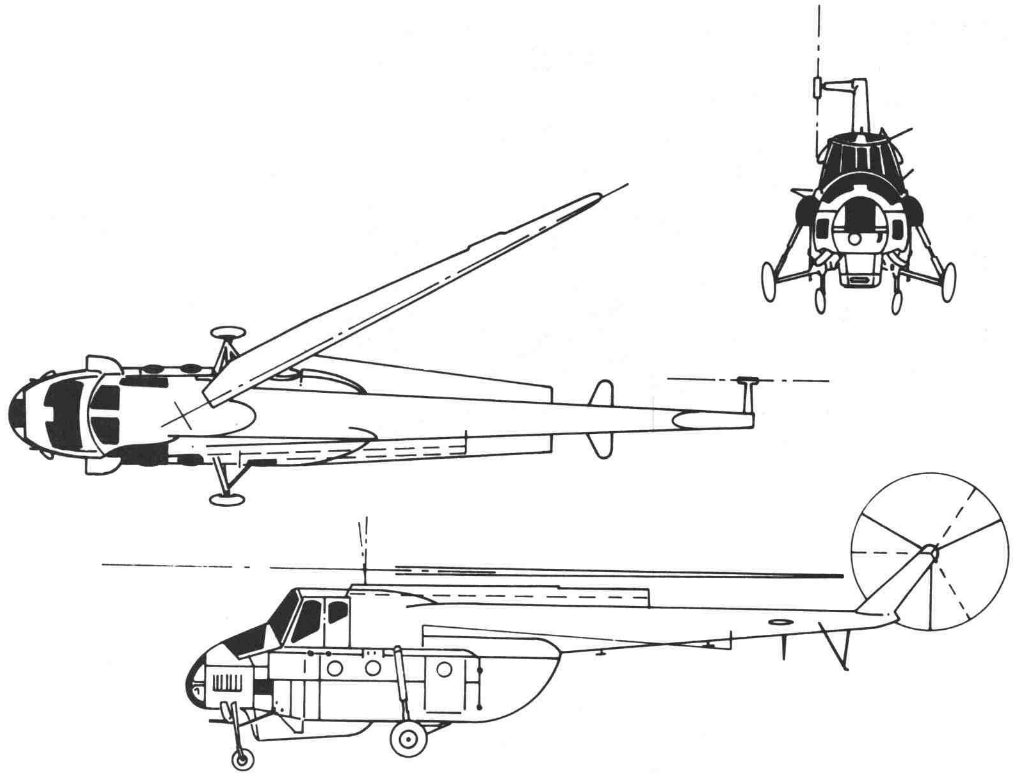
Figure 13-17. Threat Force Fighter Aircraft (Sheet 10 of 10)





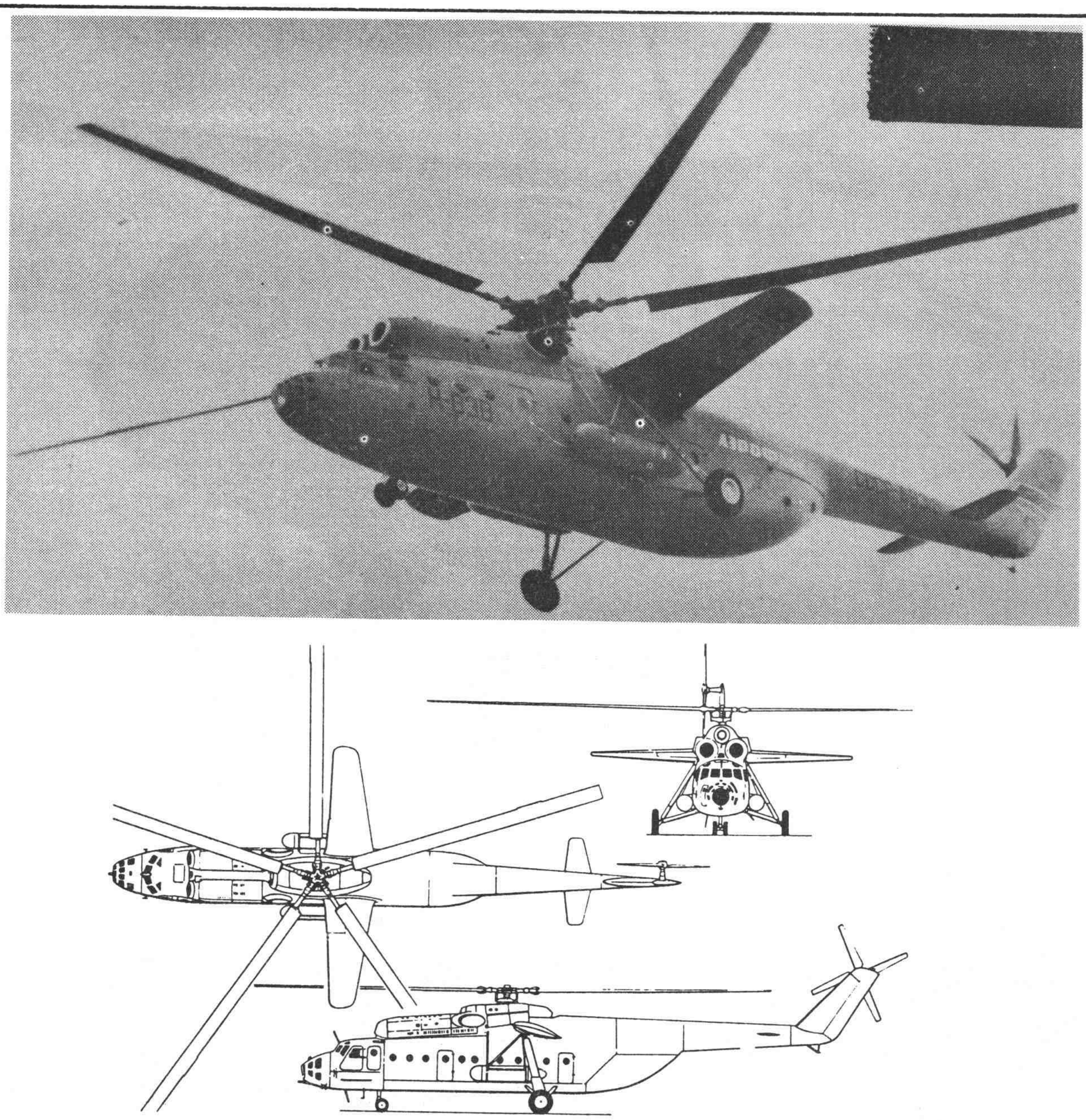
SPEED: 113 kts
RANGE: 306 to 675 km/189 to 418 m
ROTOR DIAMETER: 14.63 meters/48 feet
LENGTH: 11.89 meters/37 feet
TROOP CAPACITY: 6 to 8 pax
ARMAMENT: One 12.7-mm machinegun, two 16-shot 57-mm rocket pods or four ATGMs.
COMBAT ROLE: Light utility, armed reconnaissance, liaison, and armed support.

Figure 13-18. MI-2 HOPLITE



SPEED: 113 kts
RANGE: 274 to 463 km/170 to 287 m
ROTOR DIAMETER: 21.03 meters/69 feet
LENGTH: 16.76 meters/55 feet
TROOP CAPACITY: 14 pax
ARMAMENT: One 12.7-mm machinegun, four 16-shot 57-mm rocket pods or four ATGMs
COMBAT ROLE: General purpose, ASW
VARIANTS: Hound A, B, C.

Figure 13-19. MI-4 HOUND



SPEED: 162 kts
RANGE: 204 to 612 km/125 to 379 m
ROTOR DIAMETER: 35.05 meters/115 feet
LENGTH: 33.22 meters/109 feet
TROOP CAPACITY: 65 pax
ARMAMENT: One 12.7-mm machinegun
COMBAT ROLE: Heavy lift

Figure 13-20. MI-6 HOOK

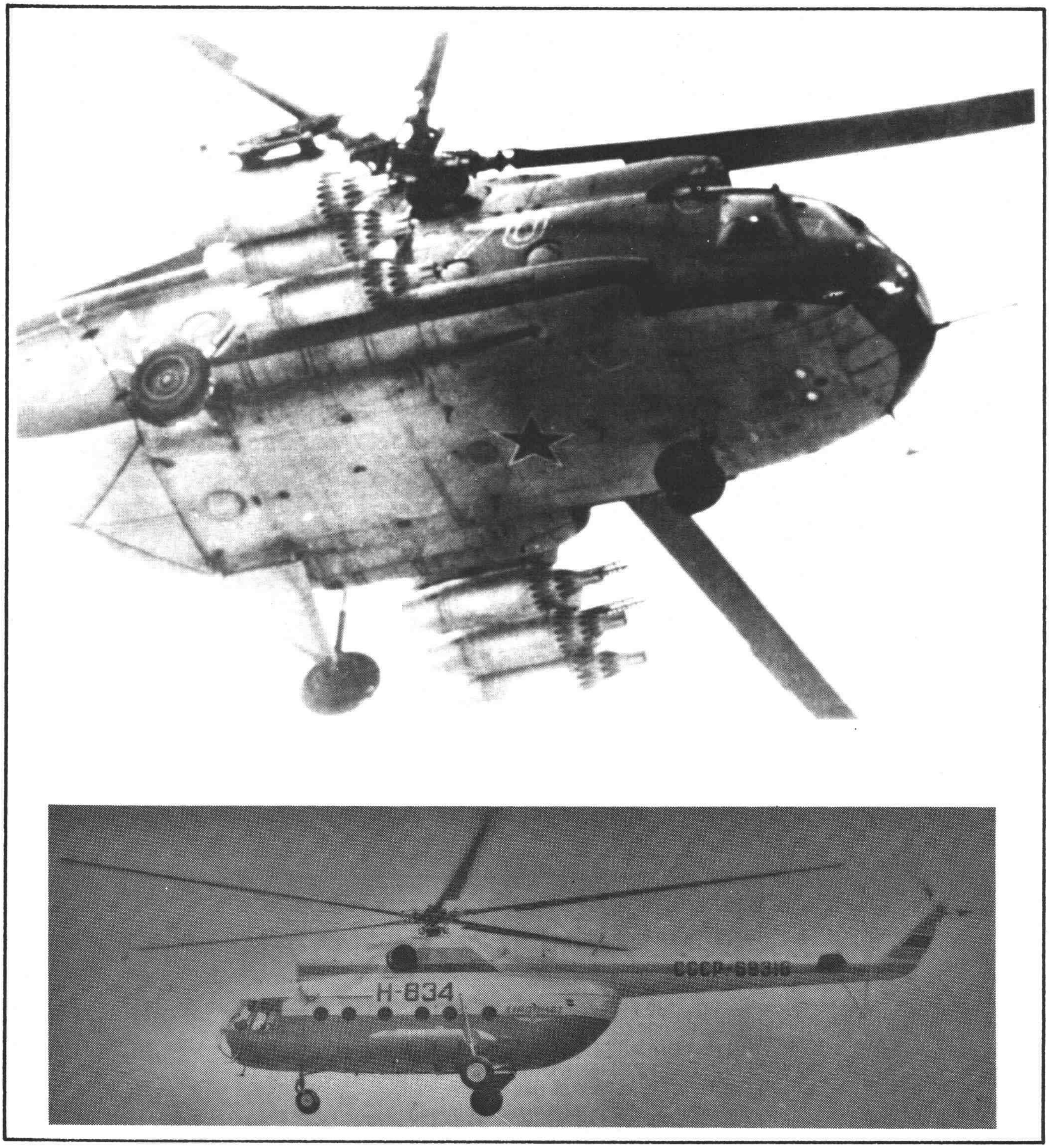
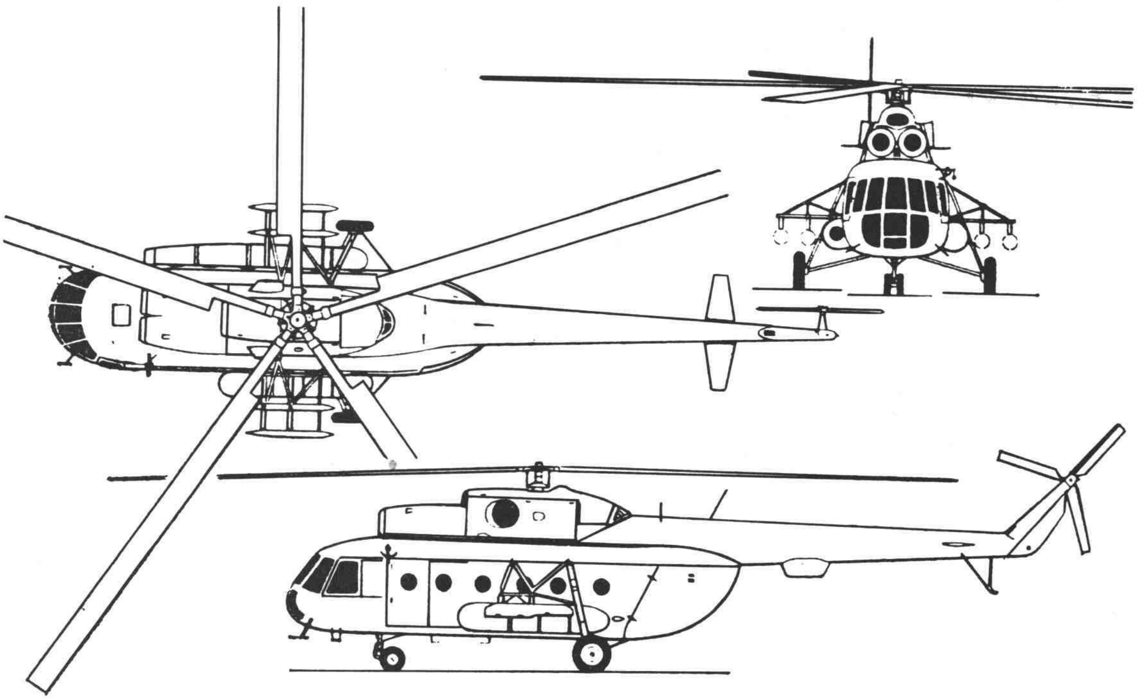
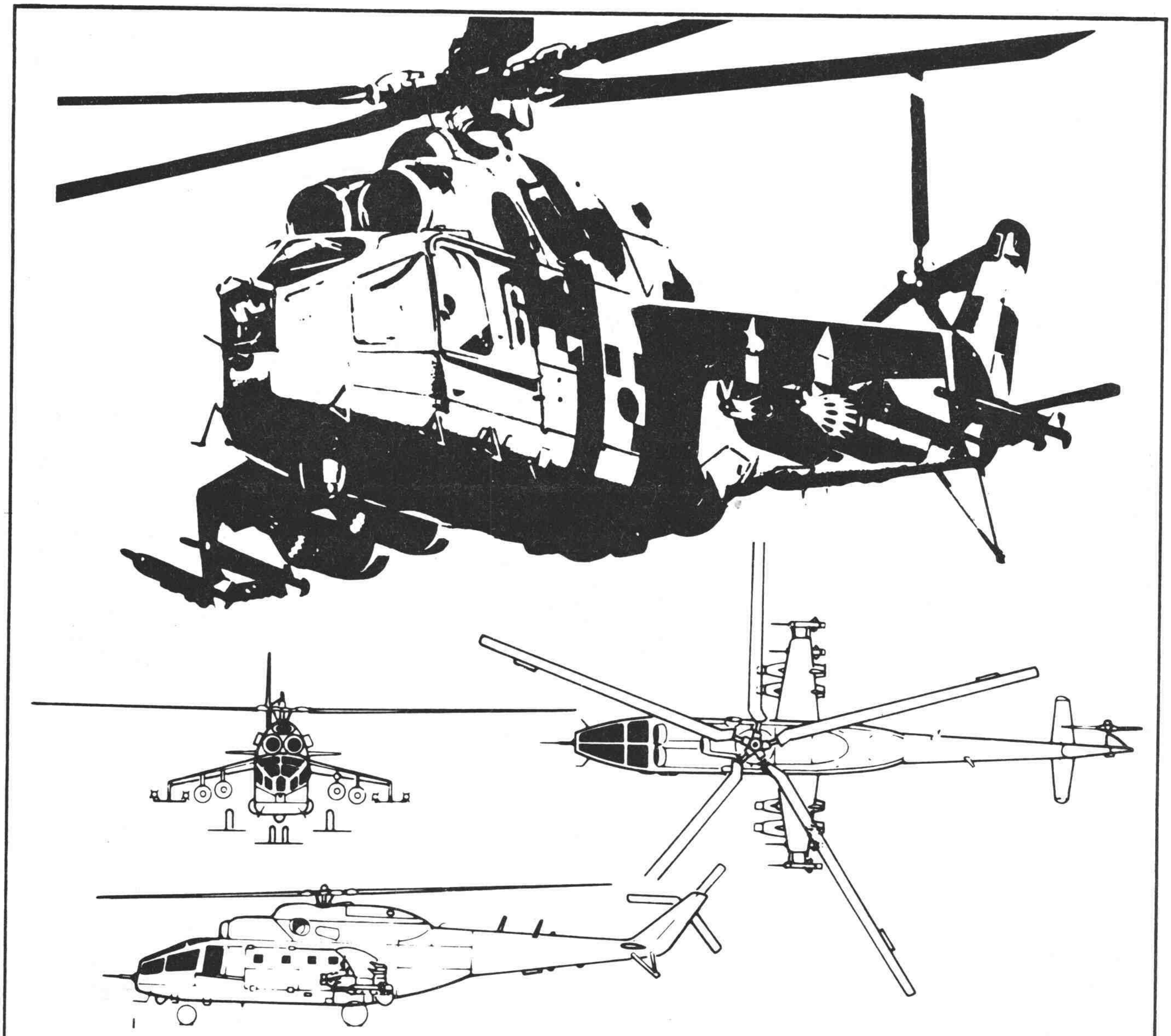


Figure 13-21. MI-8 HIP (Sheet 1 of 2)



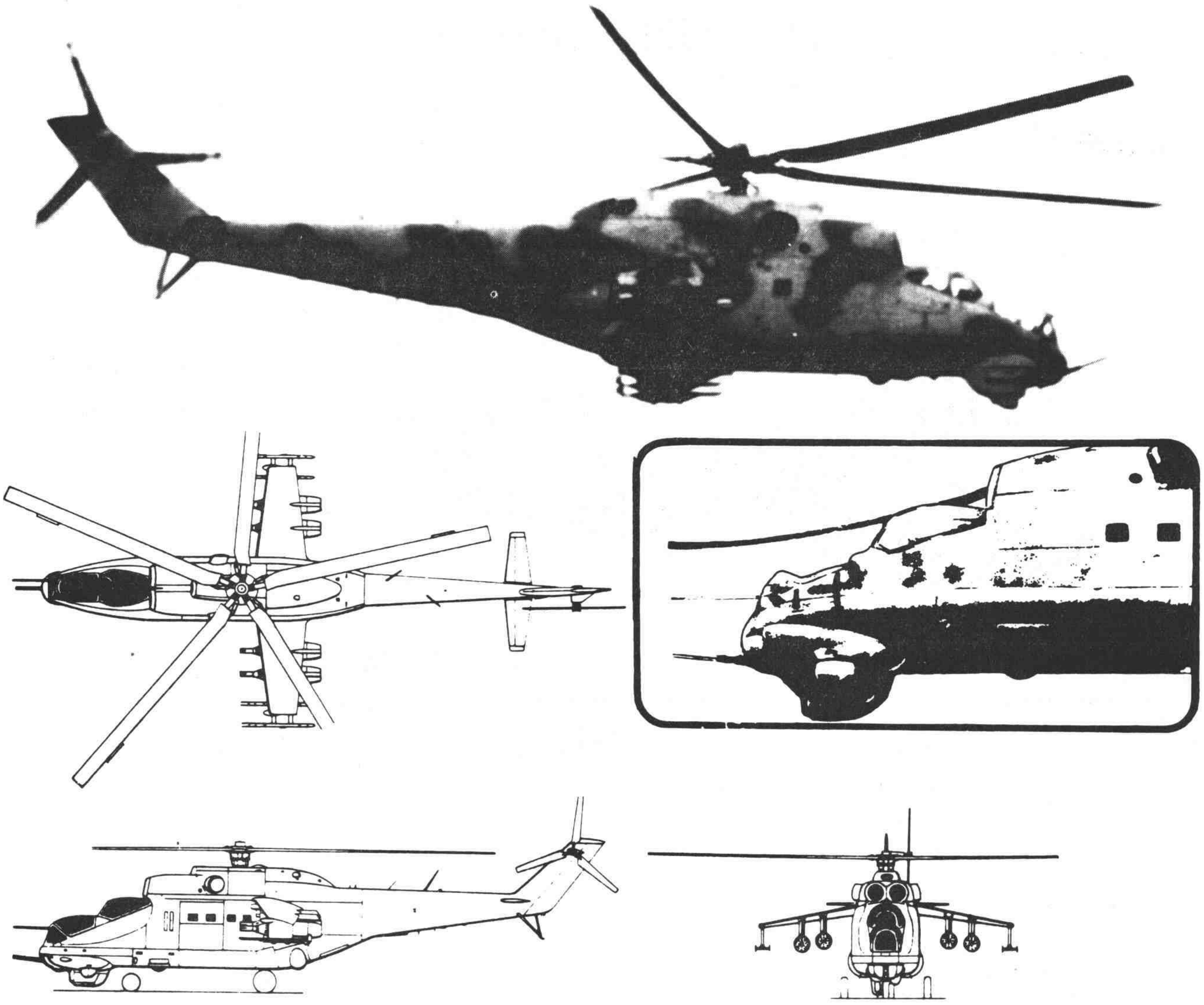
SPEED: 135 kts
RANGE: 163 to 406 km/101 to 251 m
ROTOR DIAMETER: 21.34 meters/70 feet
LENGTH: 18.29 meters/60 feet
TROOP CAPACITY: 24 to 28 pax
ARMAMENT: Four or five 7.62-mm assault rifles, one 7.62-mm machinegun, four 16-shot 57-mm rocket pods, four 550-lb bombs, two 1,100-bombs.
COMBAT ROLE: Medium utility, helicopter assault.
VARIANTS: MI-14 (HAZE) for ASW, retractable landing gear
MI-17 (HIP-H) (similar to MI-8, but tail rotor mounted on left side)
HIP C, D, E, F, J, K.

Figure 13-21. MI-8 HIP (Sheet 2 of 2)



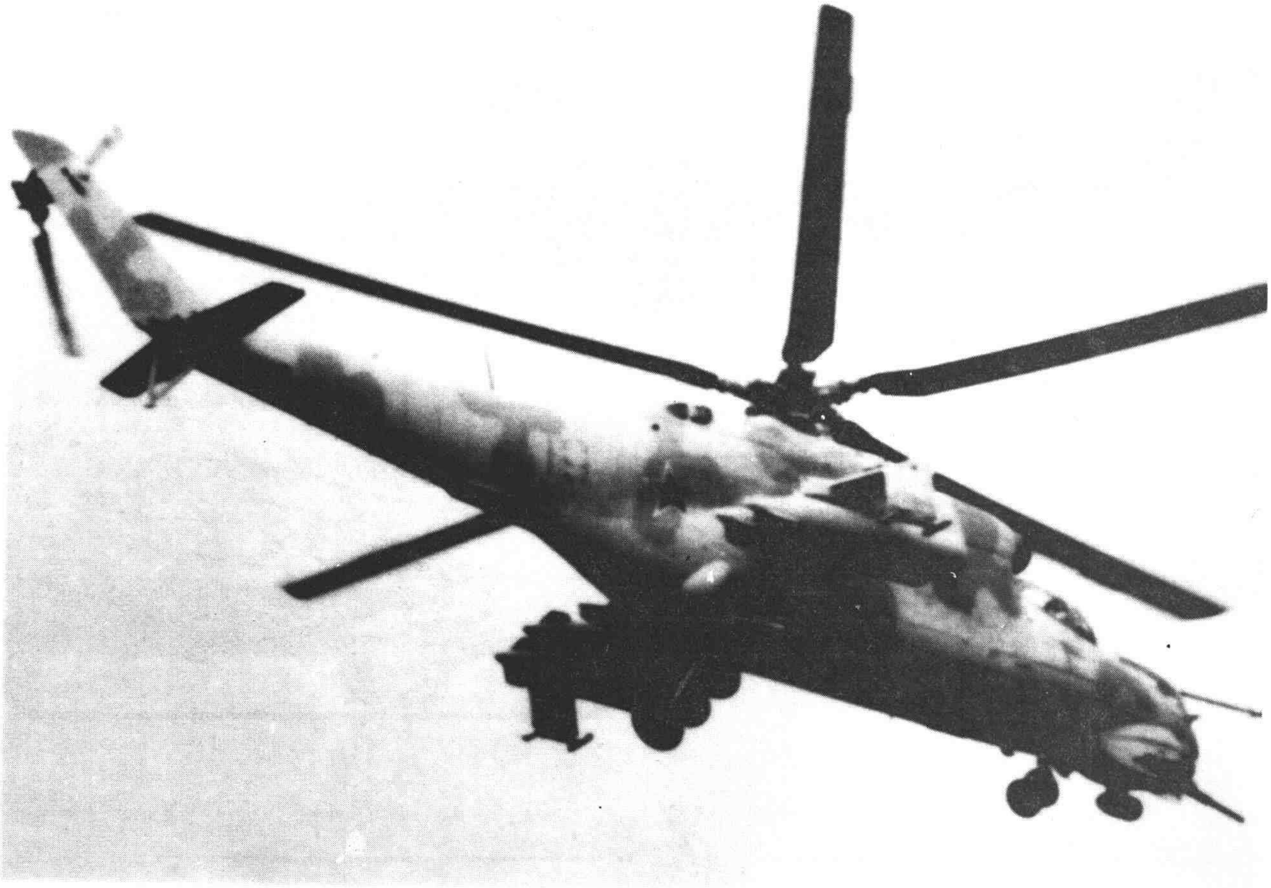
SPEED: 173 kts
RANGE: 320 km/200 m
ROTOR DIAMETER: 17 meters/56 feet
LENGTH: 19 meters/63 feet
TROOP CAPACITY: 8 pax, crew of 4
ARMAMENT: One 12.7-mm machinegun, four 32-shot 57-mm rocket pods or four bombs, two ATGM rails for AT-2/Swatter or AT-3/Sagger missiles.
COMBAT ROLE: CAS/assault transport.

Figure 13-22. MI-24 HIND A



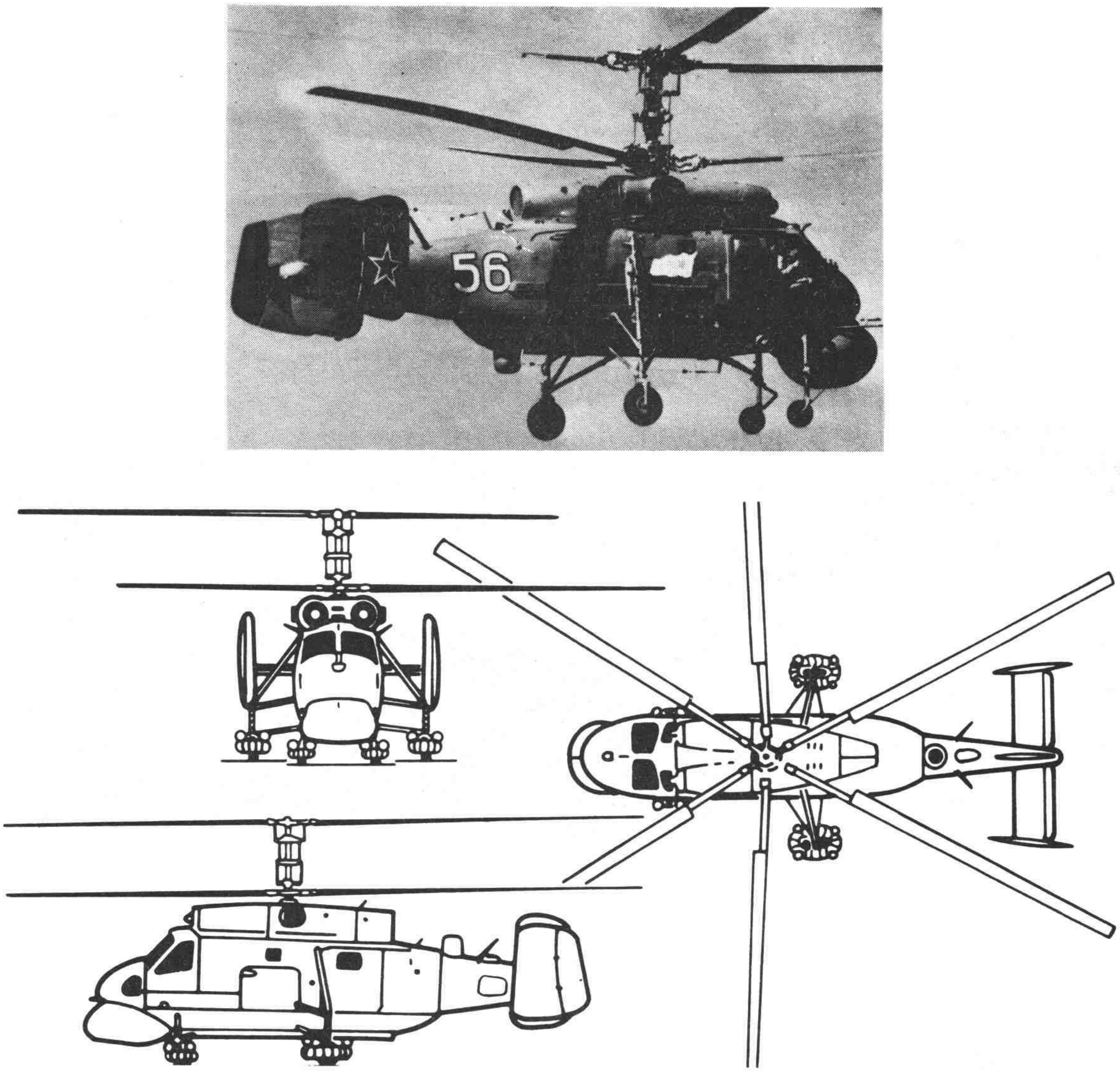
SPEED: 173 kts
RANGE: 444 km/276 m
ROTOR DIAMETER: 17 meters/56 feet
LENGTH: 19 meters/63 feet
TROOP CAPACITY: 8 to 10 pax, crew of 3
ARMAMENT: One 12.7-mm gatling gun (other armament is the same as HIND A)
COMBAT ROLE: CAS, assault transport
VARIANTS: HIND E

Figure 13-23. MI-24 HIND D



SPEED: 173 kts
RANGE: 444 km/276 m
ROTOR DIAMETER: 17 meters/56 feet
LENGTH: 19 meters/63 feet
TROOP CAPACITY: 8 to 10 pax, crew of 3
ARMAMENT: Same as HIND D, except AT-6 replaces AT-2.
COMBAT ROLE: CAS, assault transport

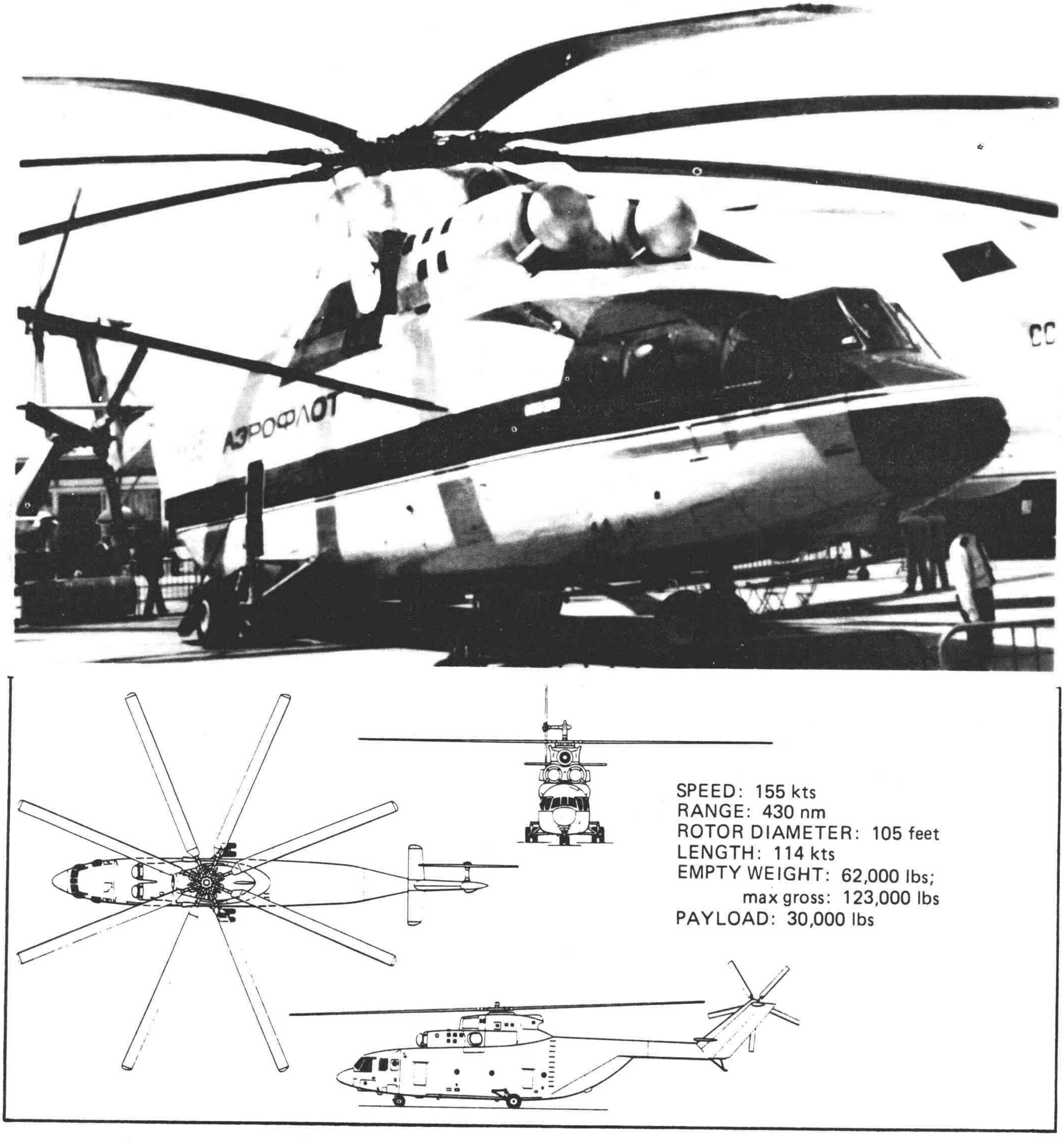
Figure 13-24. MI-24 HIND E



SPEED: 119 kts
RANGE: 290 km/150 m
ROTOR DIAMETER: 15.7 meters/51.8 feet
LENGTH: 9.8 meters/32.3 feet
TROOP CAPACITY: Crew, plus electronic equipment
ARMAMENT: Torpedoes, depth bombs, and sonobuoys
COMBAT ROLE: ASW

VARIANTS: Hormone A, B, C
KA-25K flying crane version
KA-? Helix—improved version of KA-25, 2 vertical tail fins, vice 3 on Hormone. Weapon and ASW equipment equal to or better than KA-25.

Figure 13–25. KA–25 Hormone



SPEED: 155 kts
RANGE: 430 nm
ROTOR DIAMETER: 105 feet
LENGTH: 114 kts
EMPTY WEIGHT: 62,000 lbs;
max gross: 123,000 lbs
PAYLOAD: 30,000 lbs

Figure 13-26. MIL MI-26

CLASS	KASHIN	**NATIONALITY**	USSR	**LENGTH**	143.2 m	**BEAM**	15.8 m
ARMAMENT	2 x Twin SA-N-1: 2 x Twin 76 mm: 1 x Quin 533 mm Torpedo Tubes						
ELECTRONICS	2 x Head Net'A': 2 x Peel Group: 2x Owl Screech						
ROLE	Guided Missile Destroyer (DDG)	**REMARKS**					

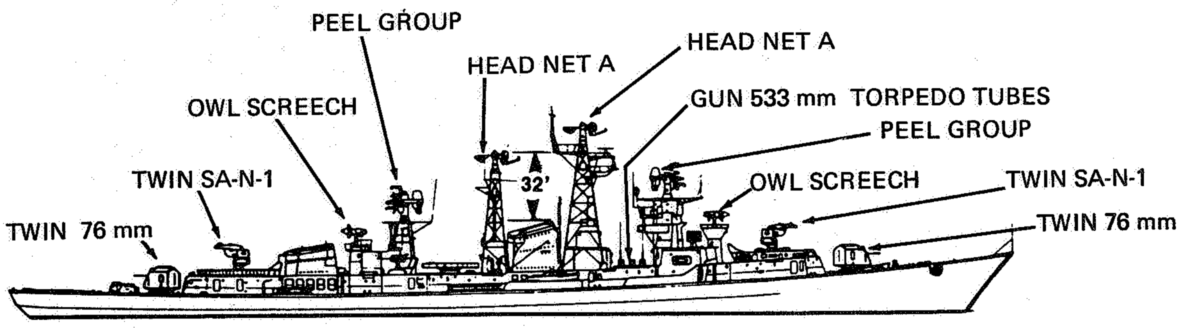


Figure 13-27. Threat Surface Vessels (Sheet 1 of 7)

CLASS	KIEV	**NATIONALITY**	USSR	**LENGTH**	232.0 m	**BEAM**	16.8 m
ARMAMENT	Possible 2 x Twin SA-N-3: 1 ASW Twin Launcher: 2 x Quad 57 mm: SA-N-4						
ELECTRONICS	Possible Top Sail: Headlight						
ROLE	Guided Missile ASW Aircraft Carrier (CVSG)			**REMARKS**			

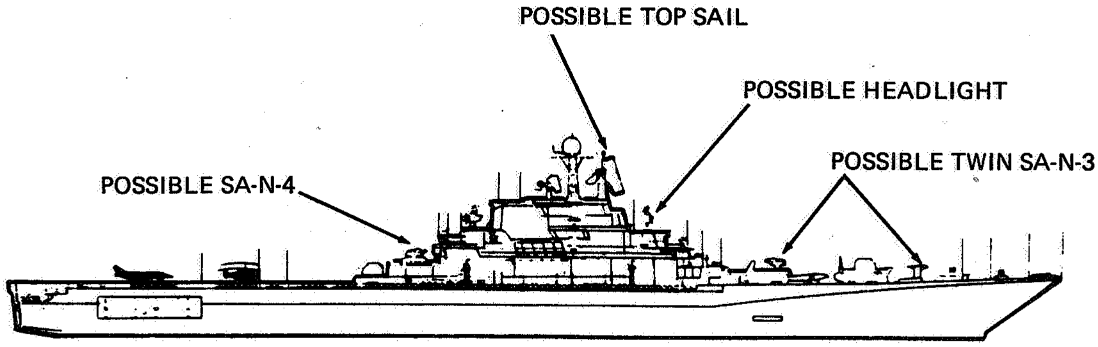


Figure 13–27. Threat Surface Vessels (Sheet 2 of 7)

CLASS	KRESTA II	**NATIONALITY**	USSR	**LENGTH**	158.4 m	**BEAM**	16.8 m
ARMAMENT	2 x Quad SS-N-10: 2 x Twin SA-N-3: 2 x Twin 57 mm: 2 x Quin 533 mm Torpedo Tubes						
ELECTRONICS	Top Sail: Head Net 'C': 2 x Head Lights 'A': 2 x Muff Cob						
ROLE	Guided Missile Cruiser (CG):	**REMARKS**					

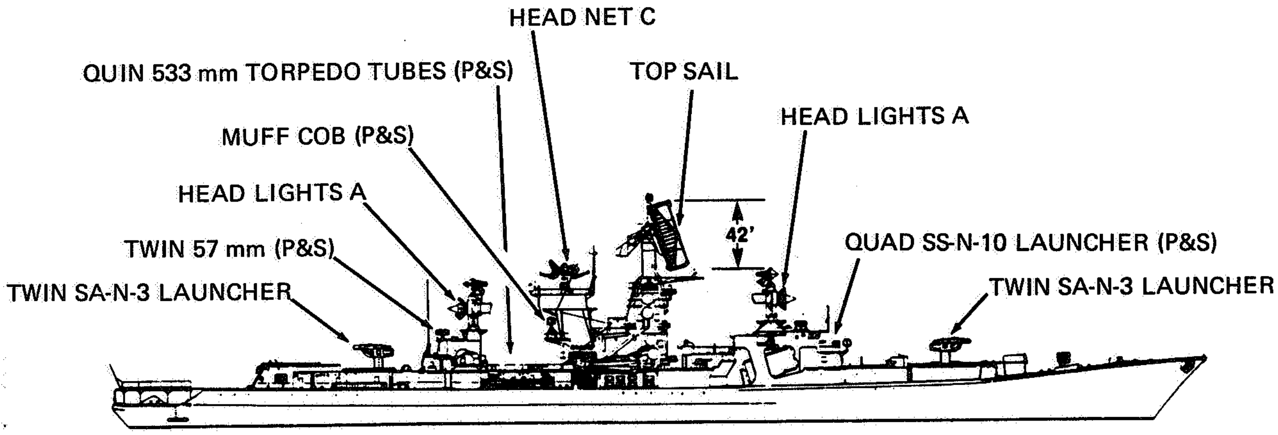


Figure 13-27. Threat Surface Vessels (Sheet 3 of 7)

CLASS	KRIVAK	**NATIONALITY**	USSR	**LENGTH**	123.4 m	**BEAM**	13.9 m
ARMAMENT	1 x Quad SS-N-10: 2 x SA-N-4: 2 x Twin 76 mm: 2 x Quad 533 mm Torpedo Tubes						
ELECTRONICS	Head Net 'C': 2 x Pop Group: Owl Screech: 2 x Eye Bowl						
ROLE	Guided Missile Destroyer (DD)	**REMARKS**					

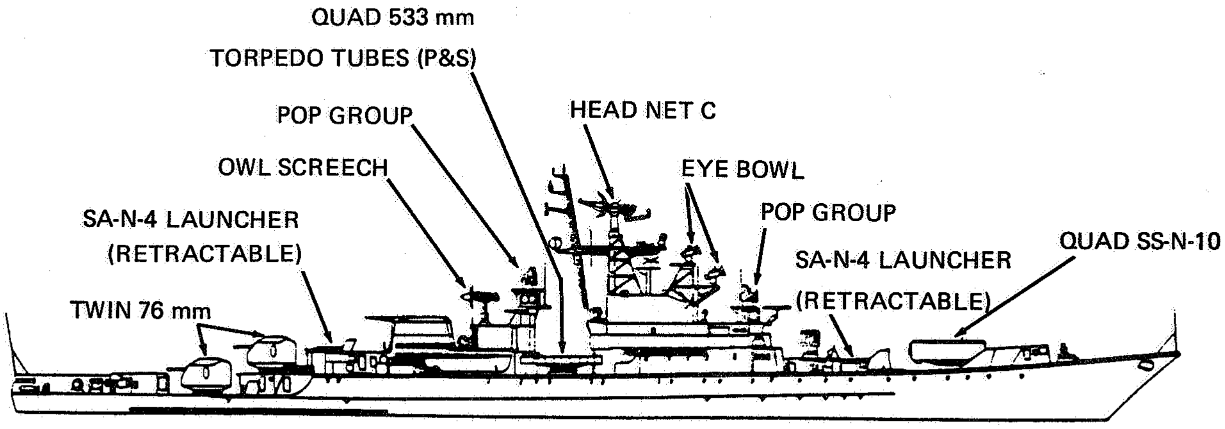


Figure 13-27. Threat Surface Vessels (Sheet 4 of 7)

CLASS	MOSKVA	**NATIONALITY**	USSR	**LENGTH**	190.5 m	**BEAM**	34.1 m
ARMAMENT	2 x SA-N-3: 1 x SUW-N-1: 2 x Twin 57 mm: 2 x Quin 533 mm Torpedo Tubes						
ELECTRONICS	Top Sail: 2 x Head Lights: Head Net 'C': 2 x Muff Cob						
ROLE	Cruiser Helicopter Carrier (CHG)	**REMARKS**	Also Fitted With Variable Depth Sonar				

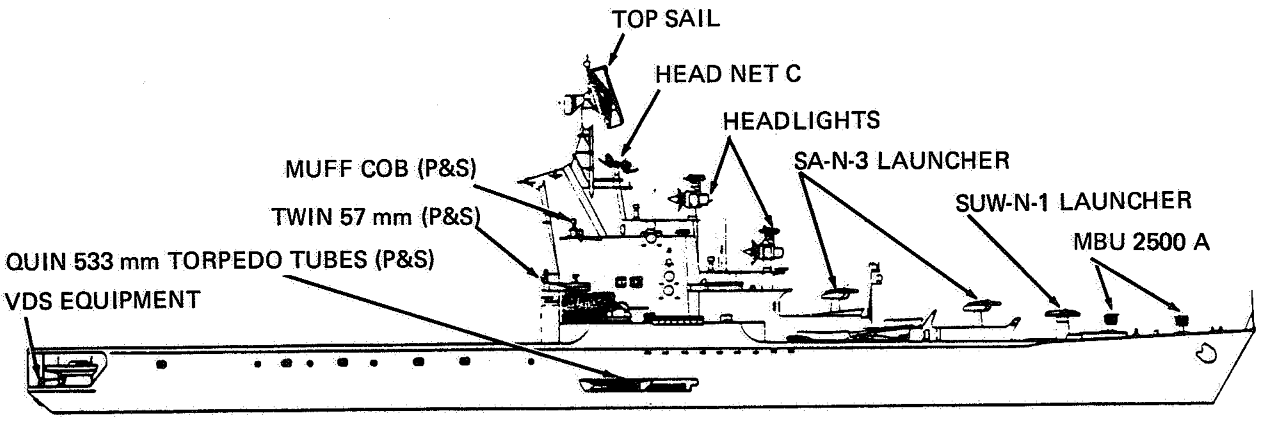


Figure 13-27. Threat Surface Vessels (Sheet 5 of 7)

CLASS	NANUCHKA	**NATIONALITY**	USSR	**LENGTH**	59.4 mm	**BEAM**	12.2 m
ARMAMENT	1 x SA-N-4: 2 x Triple SS-N-9: 1 x Twin 57 mm						
ELECTRONICS	Pop Group: Peel Pair: Muff Cob: Band Stand						
ROLE	Guided Missile Patrol Craft (PGG)	**REMARKS**					

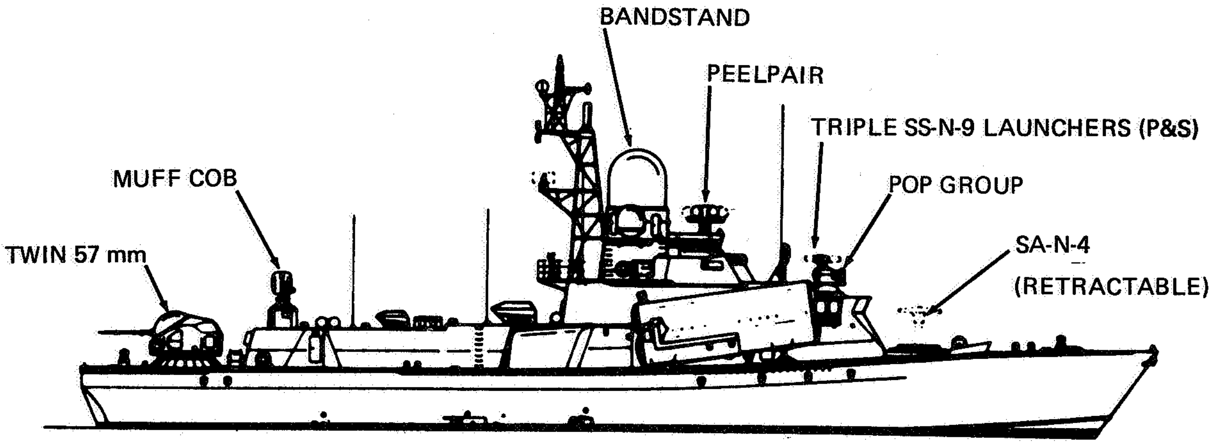


Figure 13-27. Threat Surface Vessels (Sheet 6 of 7)

CLASS	OSA (Type II)	**NATIONALITY**	USSR	**LENGTH**	39.0 m	**BEAM**	7.3 m
ARMAMENT	4 x Single SS-N-2: 2 x Twin 30 mm						
ELECTRONICS	Square Tie: Drum Tilt						
ROLE	Missile Attack Boat (PTG)	**REMARKS**					

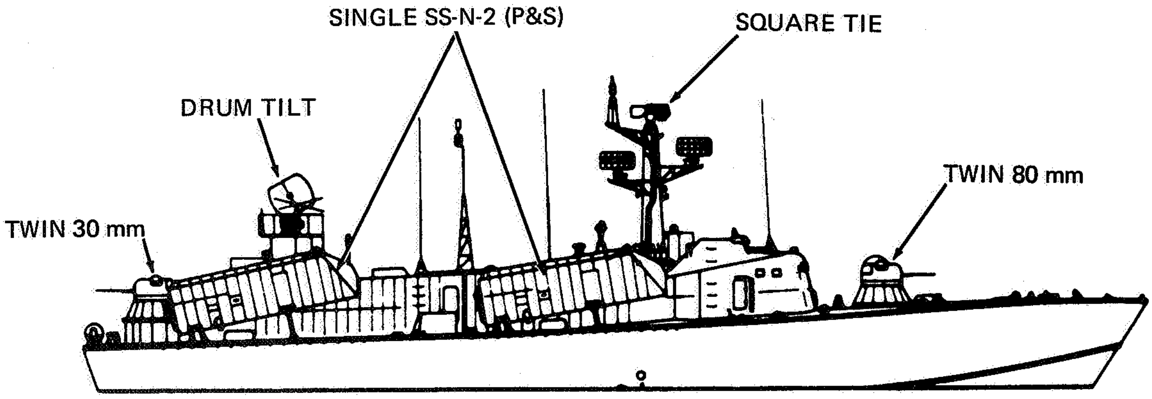


Figure 13–27. Threat Surface Vessels (Sheet 7 of 7)

WEAPONS SYSTEM	COMPANY	BATTALION	REGIMENT	DIVISION	COMBINED ARMS ARMY TANK ARMY
SA-2					X
SA-3					X
SA-4					X
SA-6				X	X
SA-7	X	X	X	X	X
SA-8			X	X	X
SA-9			X	X	
12.7-MM MG	X	X	X	X	
ZSU-23-4			X	X	
ZSU-57-2			X	X	
S-60 57-MM			X	X	X
ZPU-4 14.5-MM		X	X	X	
ZU-23-2		X	X	X	
Individual Weapons	X	X	X	X	X

Figure 13-28. Air Defense Weapons Systems in a Typical Threat Army

area systems. Equipment diversity and redundancy are emphasized in radar design and deployment. Combined radar-optical modes are used to minimize radar exposure, counter chaff, and jamming. Threat radar systems cover combat surveillance, countermortar/battery fire direction, early warning, height finding, acquisition, fire control missile guidance, and meteorology. Observers are used to fill in any gaps in radar surveillance.

13.10 THREAT TACTICS

Threat military has emphasized attainment and retention of tactical air supremacy over the battlefield. Threat army air defense artillery units are organic to regiment and division. Motorized rifle and tank division air defense regiments may be equipped with towed 57-mm S-60 and ZSU-57-2 air defense guns, respectively. These regiments are highly mobile and have excellent communication nets with fire control and radar equipment.

The ZSU-23-4 and SA-9 organic to tank and motorized rifle regiments may be found as far forward as leading tank elements, integrated into combined arms formations. Forward combat elements, especially tanks and BMPs, can be expected to use their machineguns for air defense. Also, the man-portable surface-to-air missile SA-7 is employed well forward, to platoon level, in motorized rifle, tank, and reconnaissance units.

In addition to weapons primarily designed for air defense, all combat units are trained to engage both high performance aircraft and low-flying helicopters with small arms and machineguns.

Threat forces are organized as combined arms teams as low as regimental level. For example, motorized rifle regiments are organized with a tank battalion, three motorized rifle battalions, and a howitzer battalion. They also have an antiaircraft missile and artillery

BMP - 13
SAGGER MISSILE - 50***
RPG-16-11
TANK - 31
120MM MORTAR - NONE
RIFLES AKM 7.62MM - 212
LMG PK 7.62MM (BMP) - 20
COAX MG 7.62MM (BMP & T64/72) - 41
HMG 12.7MM (T64/72) - 31
SA-7 - 9

WITH THIS POSSIBLE SUPPORT FROM REGIMENT:

- 1 OR MORE ZSU-23-4s
- 3 OR MORE BRDMs WITH SAGGER
- 122MM HOWITZERS - 6**
- 1 OR MORE ROCKET LAUNCHER BATTERIES* (120MM, 40 ROUNDS)

SA-7 - 9

*Division support.

**Divisional or regimental support.

***One SAGGER Launcher and one 73mm Smooth Bore Gun with automatic loader mounted on each BMP. Each BMP carries five SAGGERs, one mounted and four in the basic load. There are also two man-pack launchers in the battalion, each with two missiles.

Figure 13-29. Weapons in a Typical Threat Tank Battalion Reinforced by Motorized Rifle Company

BTR - 37
AT 2/3/5–2
SPG-9 - 2
RPG-16 - 35
TANK - 13
120MM MORTAR - 6
RIFLES AKM 7.62MM - 356
LMG PK 7.62MM (BTR) - 64
COAX MG 7.62MM (BTR & T64/72) 45
HMG 12.7MM (T64/72) - 13
SNIPER RIFLE SVD-7.62MM - 9
SA-7 - 9

WITH THIS POSSIBLE SUPPORT FROM REGIMENT:

- 2 OR MORE ZSU-23-4s, LOW-LEVEL, SURFACE-TO-AIR MISSILES
- 1 OR MORE BRDMs WITH AT 2/3/5
- 122MM HOWITZERS** - 6
- 1 OR MORE ROCKET LAUNCHER BATTERIES*
- SA-7 - 9
- AGS-17 - 6

*Division support.

**Divisional or regimental support.

Figure 13-30. Weapons in a Typical Threat Motorized Rifle Battalion Reinforced by Tank Company

battery, antitank battalion, reconnaissance company, engineer company, signal company, and chemical defense company. Also found in the regiment are the motor transport company, maintenance company, medical company, and supply and service platoon.

Typical battlefield disposition for tactical threat units is shown in Figures 13-31 thru 13-34. Reconnaissance units are used to locate enemy units, i.e., probe for strong points, determine enemy posture and readiness. Knowing this information allows the threat commander to decide upon a method of attack. Whenever possible he will bypass enemy strongpoints and attack them from the flanks and/or the rear. A regimental attack is organized with two objectives established: the immediate objective, i.e., penetration of forward defenses of enemy battalion, and the subsequent objective, the enemy battalion rear. Emphasis is on the combined arms team. Threat forces use massive field artillery fires to support maneuver elements. Airburst from threat field artillery fires can inhibit helicopter operations in forward areas. Within the regiment air defense artillery (ADA), priority is usually assigned to command posts and tank units.

Threat forces employ air defense artillery to protect combat formations, installations, and troop movements from air attack. ADA weapons occupy carefully selected positions in order to ambush helicopters flying terrain flight. ADA weapons are used against ground targets only in self-defense. Fire support from adjacent ADA units is provided whenever practicable.

Threat forces are trained to fight at night and during periods of reduced visibility. Basic tactics are the same under these conditions; however, objectives will not be as deep as when fighting in daylight hours and good weather.

A second echelon, usually a motorized rifle battalion, is employed in a followup role to maintain a high tempo of advance, to repel enemy counterattacks, and to exploit offensive successes of the first echelon. The march formation, direction of advance, and area of commitment are designed to exploit the success of the first echelon. Air defense weapons will most likely be included in the formation.

The tactic of using a second echelon is consistent throughout threat doctrine; therefore, even when talking of combined arms armies, there will still be a second echelon. The distance between first and second echelons depends on the tactical situation.

The motorized rifle regiment normally maintains a tank battalion as a reserve force to exploit penetrations. It may be the organic tank battalion, but usually will be the tank battalion attached to the motorized rifle regiment from the motorized rifle division's tank regiment. The reserve will travel in the vicinity of the regimental command group.

13.11 THREAT DEFENSE

Defense is only a temporary measure conducted while forces consolidate to continue an attack. It is conducted in depth from a series of strongpoints.

The threat recognizes two types of defense: hasty defense, which is most often conducted by first echelon units in an offensive action when their advance has been stopped; and deliberate defense, which is conducted when the advance is halted for more than a few hours.

13.11.1 Hasty Defense. A battalion in a hasty defense deploys in very much the same manner as a battalion advancing to contact. Hasty defense is normally used when units are forced to stop in place. Companies pull off the road or out of column, move to the nearest defensible terrain, and establish strongpoints. When tanks are leading, they may pull back to the second echelon. Antitank weapons move forward to protect flanks and gaps between strongpoints. Unit frontage remains the same as before halting — a battalion usually covers up to 3 kilometers.

13.11.2 Deliberate Defense. This is the defense most often employed. Threat forces organize the battlefield for defense into a security zone and a main defense belt as shown in Figure 13-35.

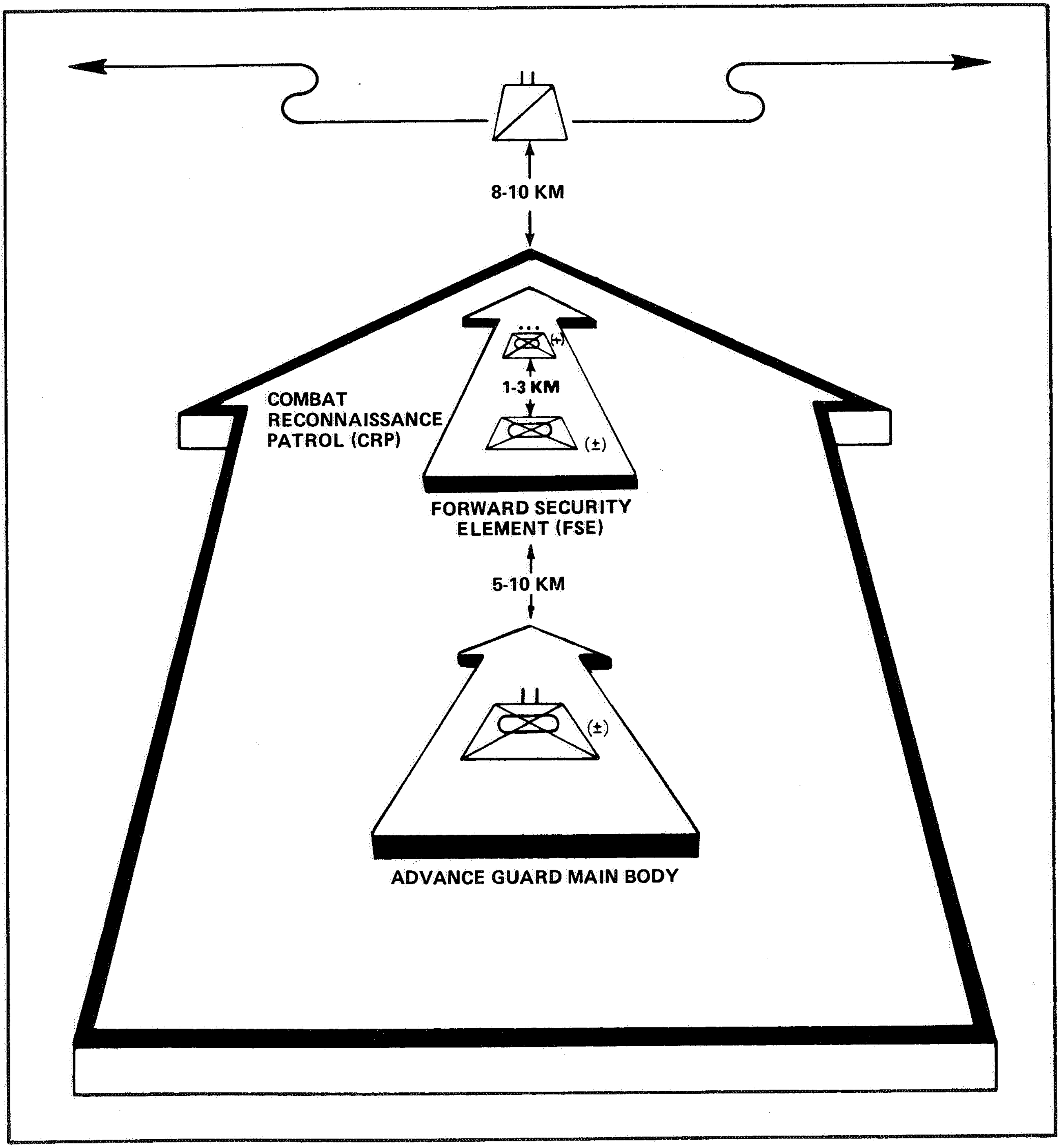

8-10 KM
(+)
1-3 KM
COMBAT RECONNAISSANCE PATROL (CRP)
(±)
FORWARD SECURITY ELEMENT (FSE)
5-10 KM
(±)
ADVANCE GUARD MAIN BODY

Figure 13-31. Weapons and Vehicles in an Advance Guard of a Motorized Rifle Division

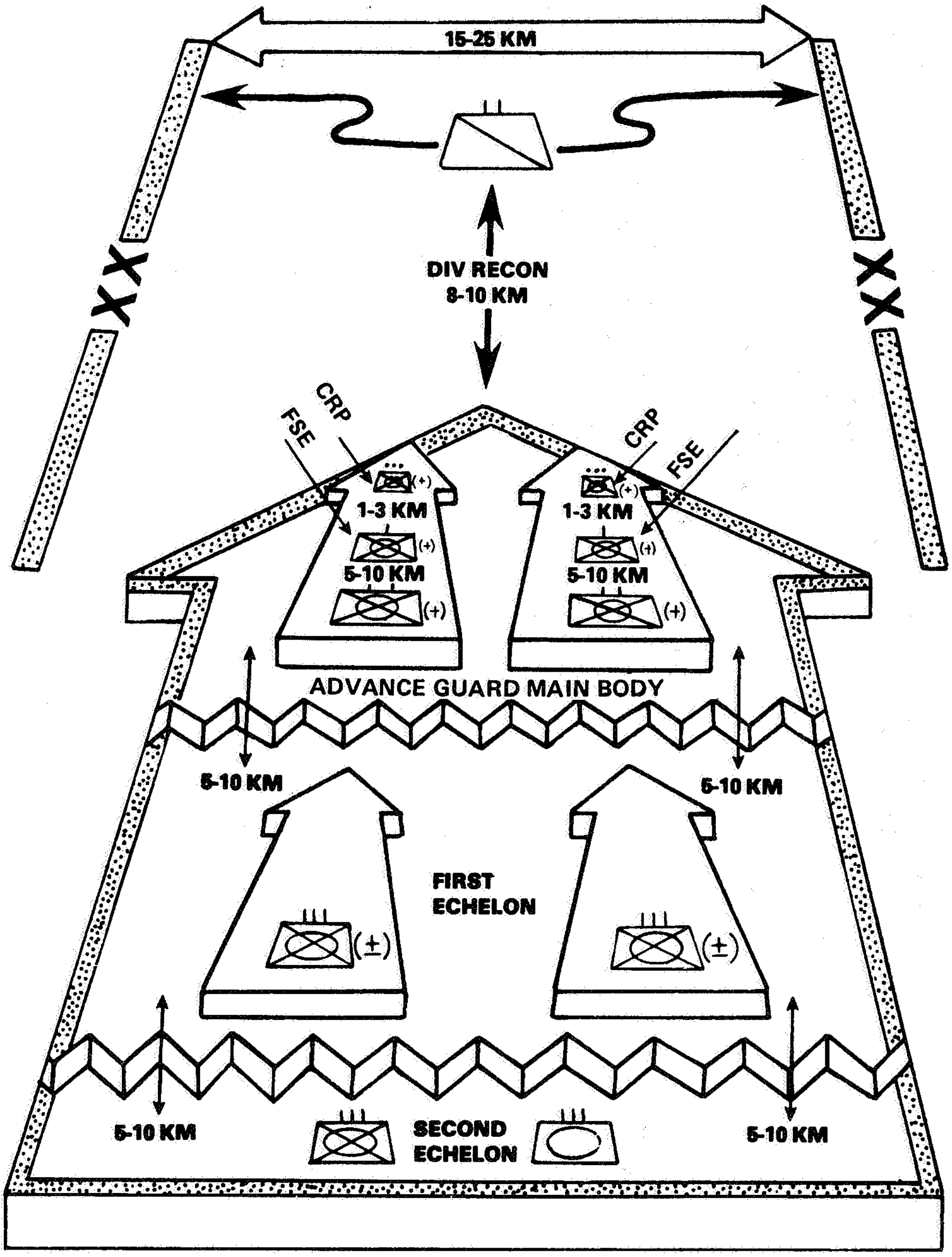
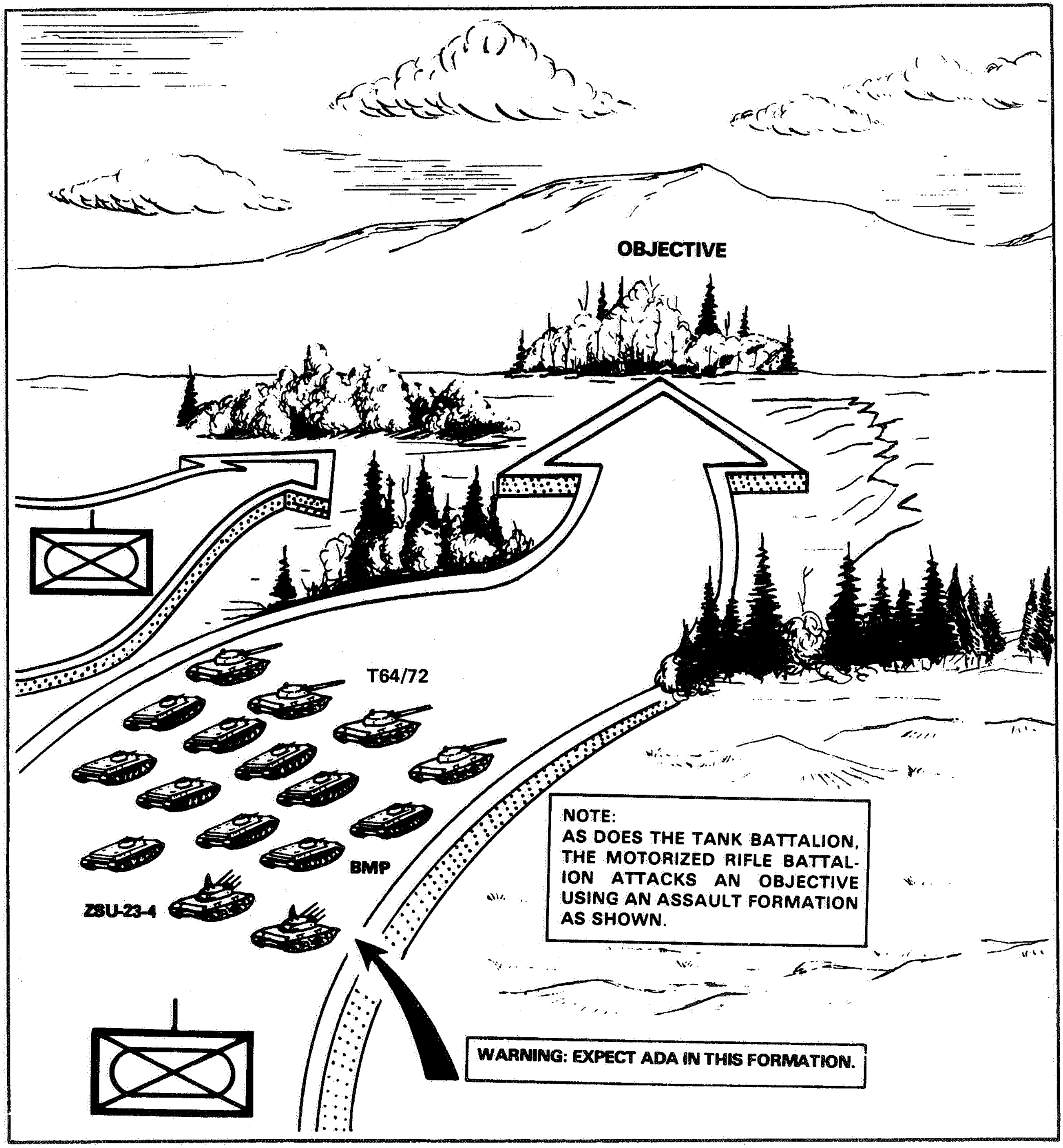


Figure 13-32. Motorized Rifle Division Advancing to Contact



NOTE:
AS DOES THE TANK BATTALION, THE MOTORIZED RIFLE BATTALION ATTACKS AN OBJECTIVE USING AN ASSAULT FORMATION AS SHOWN.

WARNING: EXPECT ADA IN THIS FORMATION.

Figure 13-33. Motorized Rifle Battalion Attacks

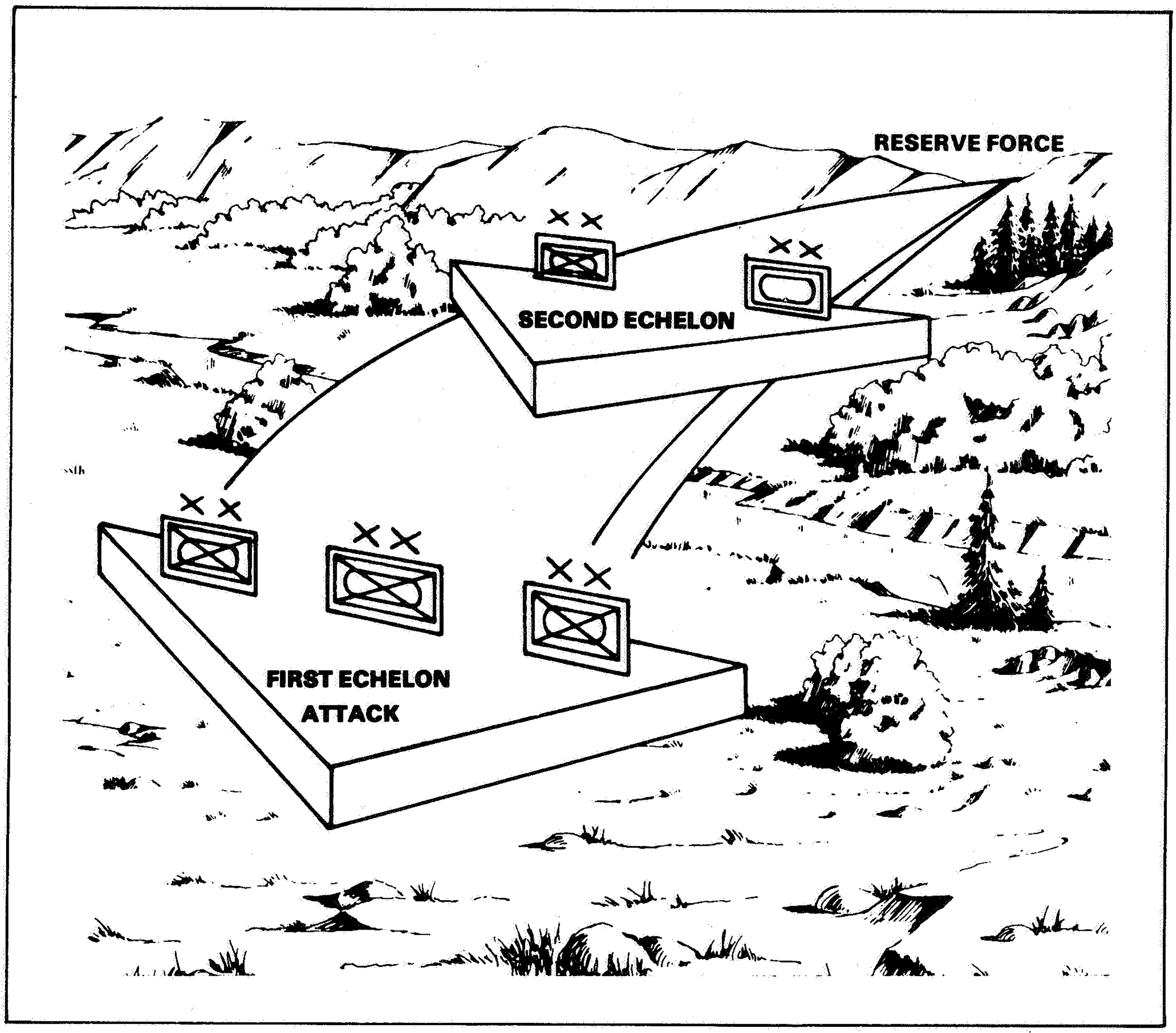


Figure 13-34. Echelons of the Combined Arms Army in the Attack

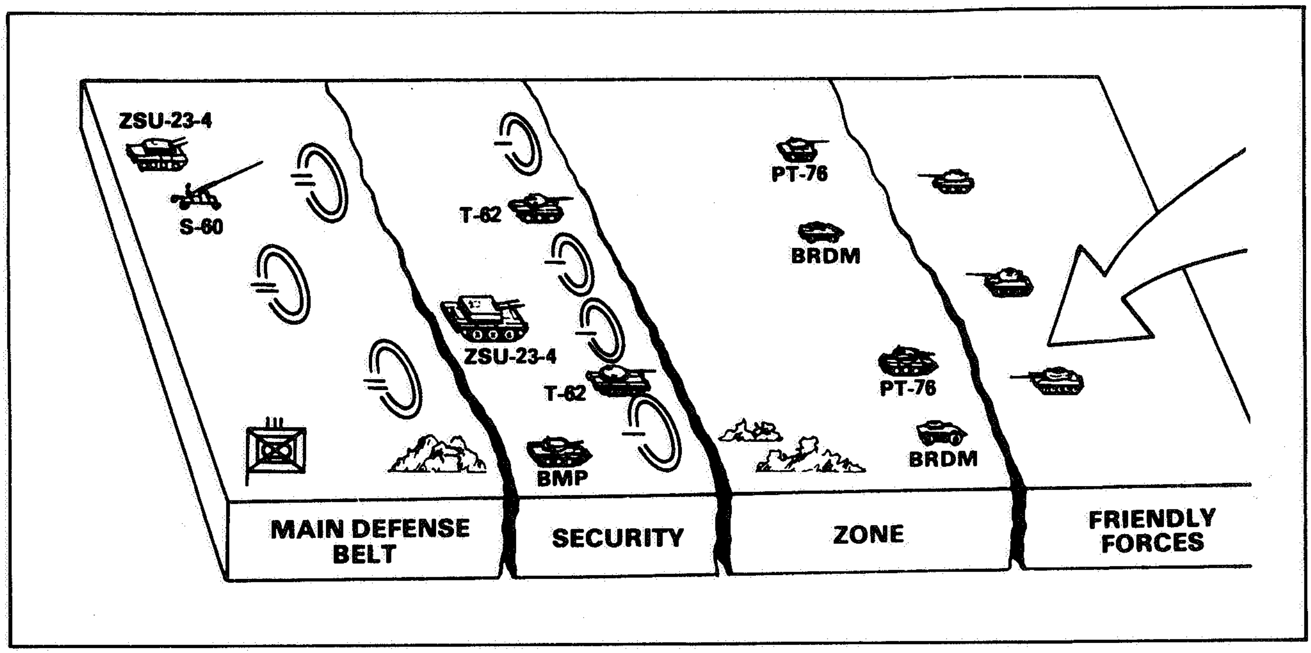


Figure 13-35. Threat Defense in Depth

The security zone begins about 20 to 25 kilometers forward of the main defense belt. The first forces encountered are covering troops with the mission of locating attacking forces and determining the axis of the main attack. Also, there are battalion-sized or company-sized elements in this zone with the mission of forcing the attacker into kill zones.

Elements from main defense second echelon battalions are also located in the security zone, approximately 3 to 5 kilometers in front of main defense units. They are positioned to deceive the attacker on the location of the main defense system and to weaken him early in the battle.

The main defense belt consists of battalion strongpoints on likely avenues of approach. Time permitting, engineers reinforce terrain with minefields and barriers. Fires are planned on avenues of approach, flanks, on and to the rear of all defensive positions. Defensive fires are provided by artillery, mortars, ATGMs, and by tanks used in an antitank role. There are two lines of defense within a battalion defensive position. A typical battalion defensive sector is illustrated in Figure 13-36.

The first echelon of the battalion consists of two reinforced companies. These companies are deployed in platoon strongpoints as shown. The second echelon is formed by the third company, spread across the battalion sector approximately 1 kilometer behind the first echelon companies. If the sector is very wide or terrain is not suitable for organizing strongpoints in depth, the battalion will not use a second echelon.

A company defensive position in a threat battalion strongpoint may be organized as shown in Figure 13-37. In some instances, BMPs of forward platoons will be positioned with the rear platoon, providing overwatching fires. The infantry prepares two- and three-man defensive positions as quickly as possible. Communication trenches are dug between platoons and company headquarters. Alternate

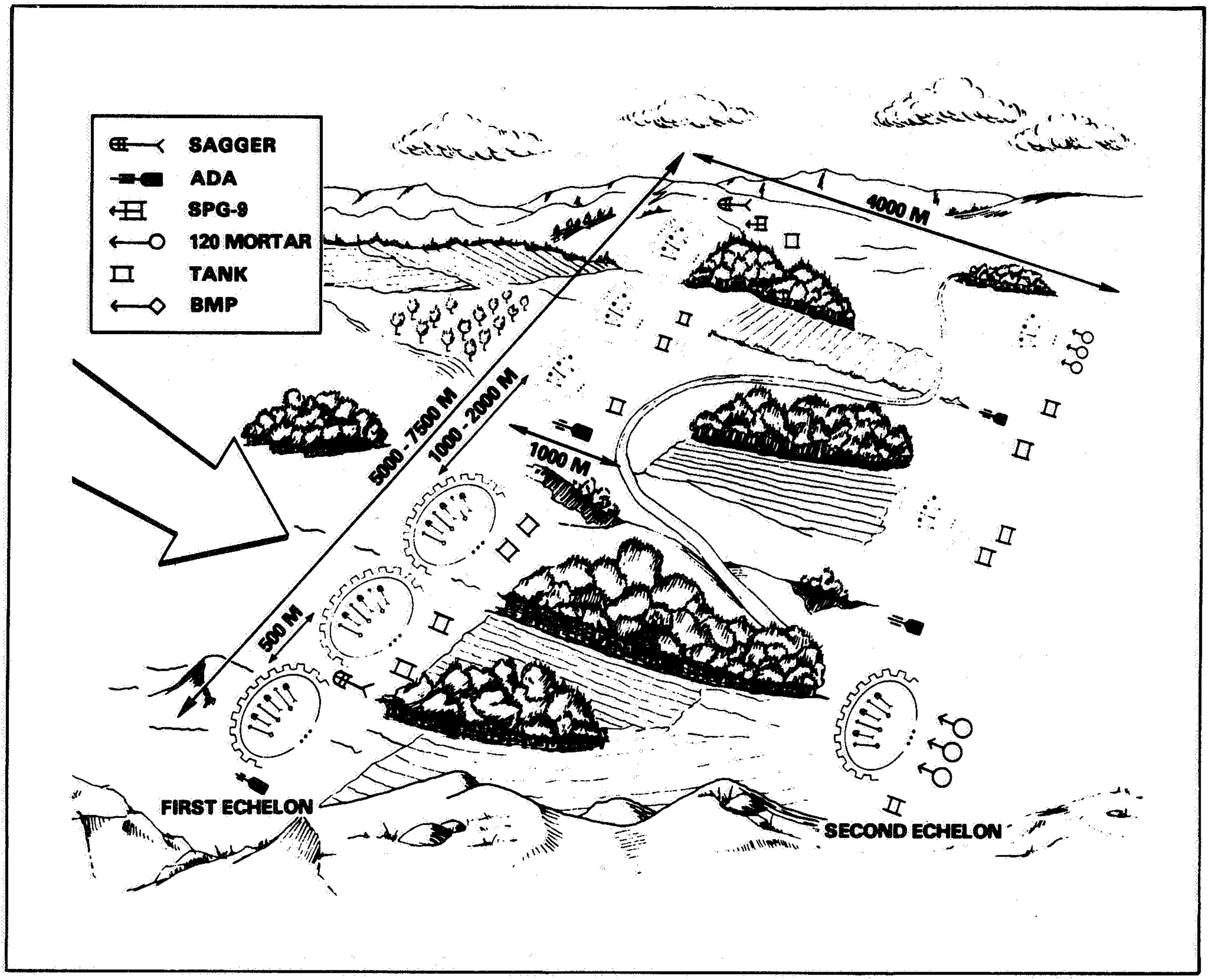


Figure 13-36. Battalion Main Defensive Belt Organization

positions are prepared; BMPs and tanks are dug in, using unit resources (dozer blades and explosives). A machinegun manned by the driver may be set up on a ground mount 100 meters in front of the tank. This position is connected to the tank by a trench.

Any penetration into the main defensive belt (Figure 13-38) will be counterattacked by elements of the regimental tank battalion held in reserve for that purpose. The objective of the counterattack by the reserve is destruction of the enemy force. Priority for air defense may be assigned to the reserve. ADA will normally accompany the tank battalion in the counterattack.

13.11.3 Defense Against Amphibious Attack. The threat will deploy his motorized rifle battalion (MRB) to occupy a coastal defensive position 2 to 5 kilometers in width and up to 3 kilometers in depth. Maximum firepower

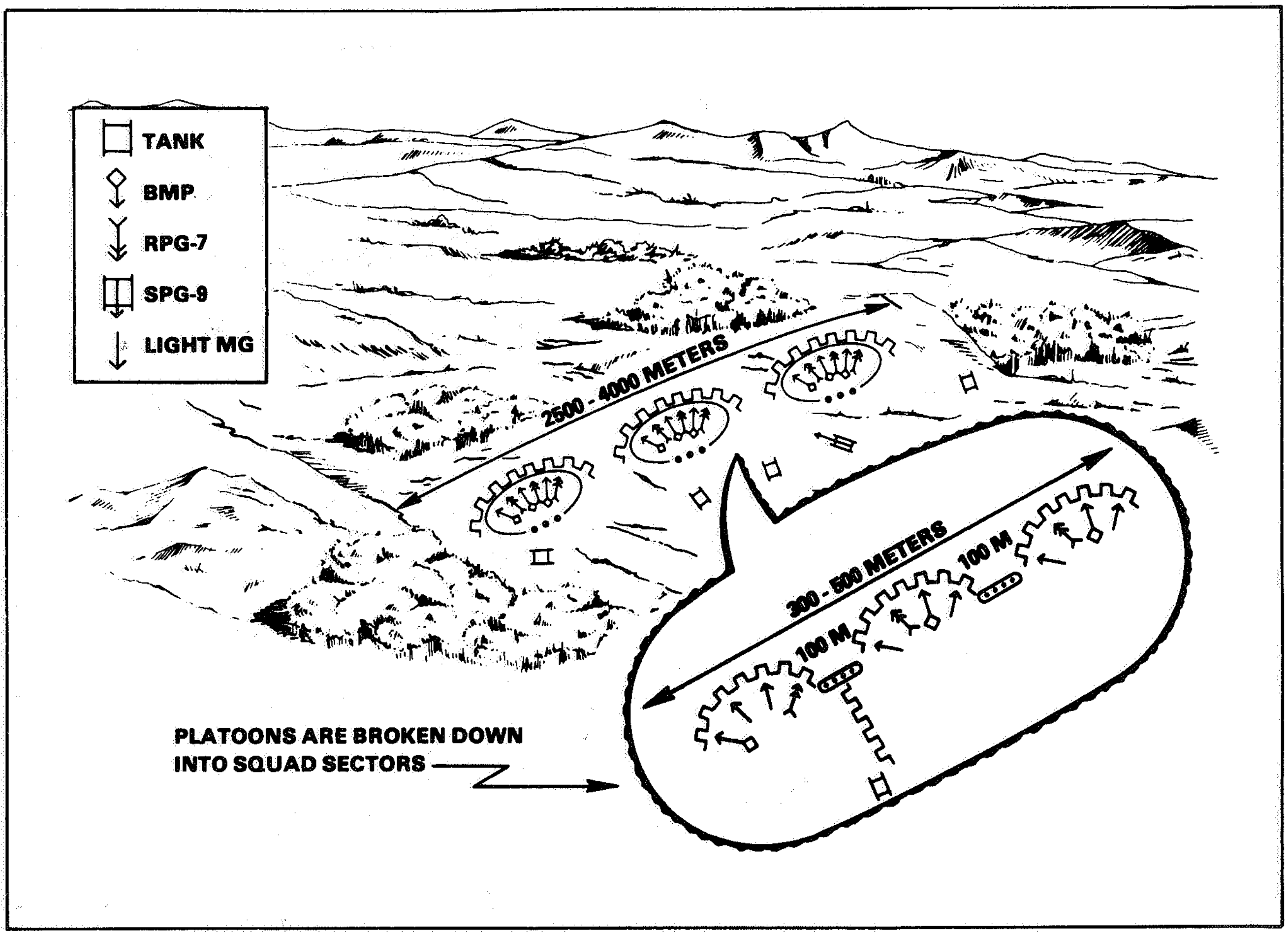


Figure 13-37. Company Defensive Organization

will be located forward in an attempt to prevent the first wave of the assaulting force from even reaching the beach. Antitank and artillery weapons will be located where they can engage targets still far from the beach. An MRB reinforced with ZSU-23/4s would deploy these weapons to defend the forces near the beach from air strikes. If the first wave succeeds in reaching the beach, the Soviet concept is to launch its reserve, which will include tanks, to counterattack before the second wave can reach the shore. Soviet forces defending a beach will be very stubborn in giving up any ground. Soviet naval infantry forces may be assigned coastal defense missions.

13.12 THREAT VULNERABILITIES

Although threat forces have one of the best-equipped and well-trained armies in the world, they can be defeated. Every weapon and weapons system has weaknesses and vulnerabilities which can be exploited. Threat force vulnerabilities include:

1. Light armor is vulnerable to most weapons found on the modern battlefield.

2. Tanks are vulnerable to multiple kills because of crew placement. Fuel and ammunition stored side by side in the crew compartment are a lethal combination when hit.

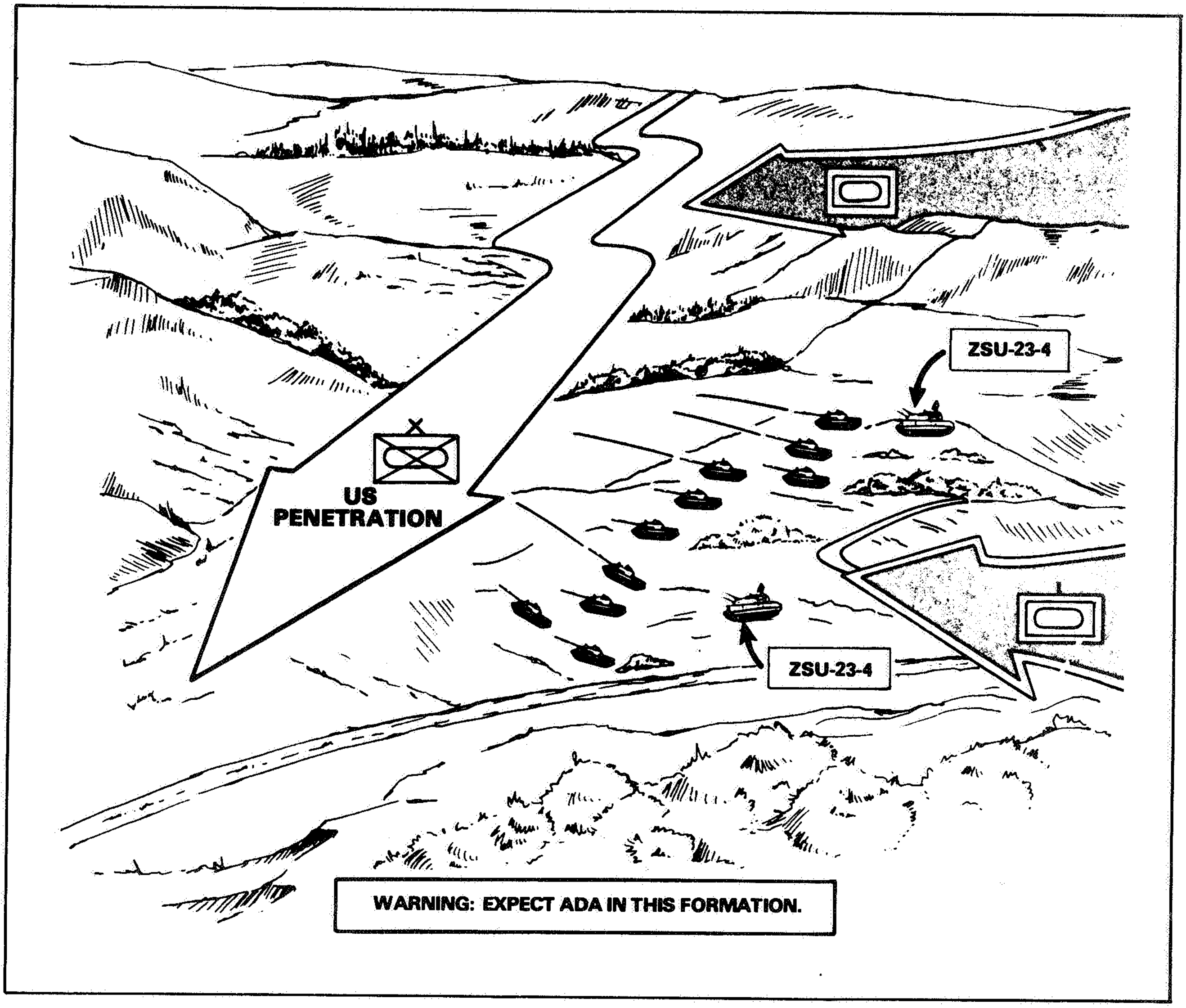

ZSU-23-4
US
PENETRATION
ZSU-23-4
WARNING: EXPECT ADA IN THIS FORMATION.

Figure 13-38. Penetration of the Threat Main Defensive Belt

3. Self-propelled ADA guns like the ZSU-23-4 and ZSU-57-2 with radar antenna and no overhead cover for crews are especially vulnerable to artillery with VT fuzes.

4. Towed artillery is vulnerable to counterfire.

5. Weapons which are guided like the SAGGER missile can be defeated by obscuring the gunner's vision.

13.13 THREAT ELECTRONIC WARFARE

Threat forces have assigned a high priority to disrupting and disorganizing the use of radios, radar, or any electronic emitter used in command and control, navigational aids, and fire control systems. A threat force can locate, identify, and exploit rapidly all types of communication and noncommunication transmitters over a wide range of frequencies. Threat forces include special purpose electronic warfare units with both airborne and ground-based EW equipment including electronic emitters and infrared detectors.

Threat forces conduct intercept operations to determine the composition of an opponent's forces, the electronic order of battle, and to gain electronic information regarding emitters in order to plan effective countermeasures. Threat forces are adept at locating, recording, and analyzing the technical characteristics of intercepted signals as well as the specific operating procedures employed on the nets. Such activities are particularly effective when the opponent's communications operations are careless or imprecise, or when operations are conducted under pressure, as in a combat situation.

Threat forces can be expected to fire on a direction-finding fix alone. They set a high priority on fixing emitters associated with command and control and weapons systems. Once a transmitter is located, threat artillery will fire a barrage to cover a wide area at the suspected location. The expense of the ordnance is worth the possible gain despite the possibility of a deception operation.

Threat force doctrine advocates deception and jamming operations as a complement to firepower and maneuver capabilities. Such operations are directed at communication nets in which signals are weak, where there is natural background interference or some atmospheric disturbance, or where there exists an atmosphere of confusion. Threat forces possess a significant capability to direct electronic deception operations against radio communication circuits and electromagnetic radiations emanating from noncommunication emitters. In deception operations, they emphasize surprise — intruding into the most important communication nets and concentrating on the most critical phase of a combat operation.

Threat force units use either spot (narrowband), sweep, or barrage (broadband) jamming of tactical radio nets when jamming is more desirable than the intelligence that can be obtained from monitoring the nets. Even though specialized jamming equipment is in use, threat force units capitalize on the fact that any transmitter is a potential jammer. Jammers are displaced from the forward edge of the battle area to rear areas according to the strength of the jammer.

Jamming by threat force operators usually involves a period of jamming followed by a brief listening period to determine how effective the jamming has been. Threat force doctrine is based on the principle that jamming is most effective when the opposing force does not know about it; therefore, threat force operators are trained to increase jamming gradually instead of relying on sudden bursts of power.

PART V

Special-Purpose Weapon and Equipment

Chapter 14 — Electronic Warfare Principles
Chapter 15 — Electronic Warfare Equipment
Chapter 16 — Chemical, Biological, and Radiological Missions

CHAPTER 14

Electronic Warfare Principles

14.1 SUSCEPTIBILITY REDUCTION

The increasing use of electronic radiation and receiving devices for target acquisition and tracking and for the guidance and control of air defense systems has led to a major emphasis on countermeasures to the electronic threat elements. The phrases electronic warfare (EW), electronic countermeasures (ECM), and electronic counter-countermeasures (ECCM) have become familiar to anyone even remotely associated with aircraft tactics. Almost all of the systems use a particular region of the electromagnetic spectrum shown in Figure 14-1. The earliest electronic systems used the radio portion of the electromagnectic frequency spectrum for target detection and tracking. The systems are called radio detection and ranging (radar). The many new detection, tracking, and homing devices (i.e., electro-optical and laser) rely on other portions of the electromagnetic spectrum shown in Figure 14-1, from the lowest radio frequencies through microwaves, infrared, visible light, and out to ultraviolet. Figure 14-2 compares the microwave frequency spectrum to its associated band. Aircraft survivability is now dependent on countermeasures that must cover this ever-expanding frequency spectrum.

Many different types of countermeasures have been and are being developed to degrade the effectiveness of the various elements of the hostile air defense systems. For example, it has been shown that the probability of kill could be expressed as the product of a series of individual probabilities (i.e., $P_K = P_A \cdot P_T \cdot P_D \cdot P_{K/H}$). All of these terms except the probability of kill given a hit ($P_{K/H}$) can be influenced in some manner by countermeasures. The probability of detection and tracking (P_T) can be reduced by tactics which employ terrain masking to reduce the probability that the aircraft will intersect the line of sight to the threat. The probability of detection can be affected by passive measures which reduce or disguise the *signatures* of the target Countermeasures in the form of onboard or offboard electronic jamming of the transmitted signal may be actively employed to reduce the probability of a launch by degrading the target tracking systems being employed. Similarly, the probability of successful missile guidance may be decreased by jamming missile command guidance links. Proximity fuze jamming techniques may cause premature detonation or disabling of the weapon arming system, thus reducing the probability of a successful detonation. The effects of these countermeasures techniques (usually synergistically) enhance the probability of survival in the hostile environment.

There are many kinds of countermeasures available today for reducing the susceptibility of the aircraft. Most air defense countermeasures techniques can be grouped into the following six categories:

1. Noise jammers and deceivers
2. Aircraft signature suppression
3. Threat warning
4. Expendables
5. Tactics
6. Threat suppression.

All of these categories, except some aspects of signature suppression and tactics, involve some piece of equipment (device or armament)

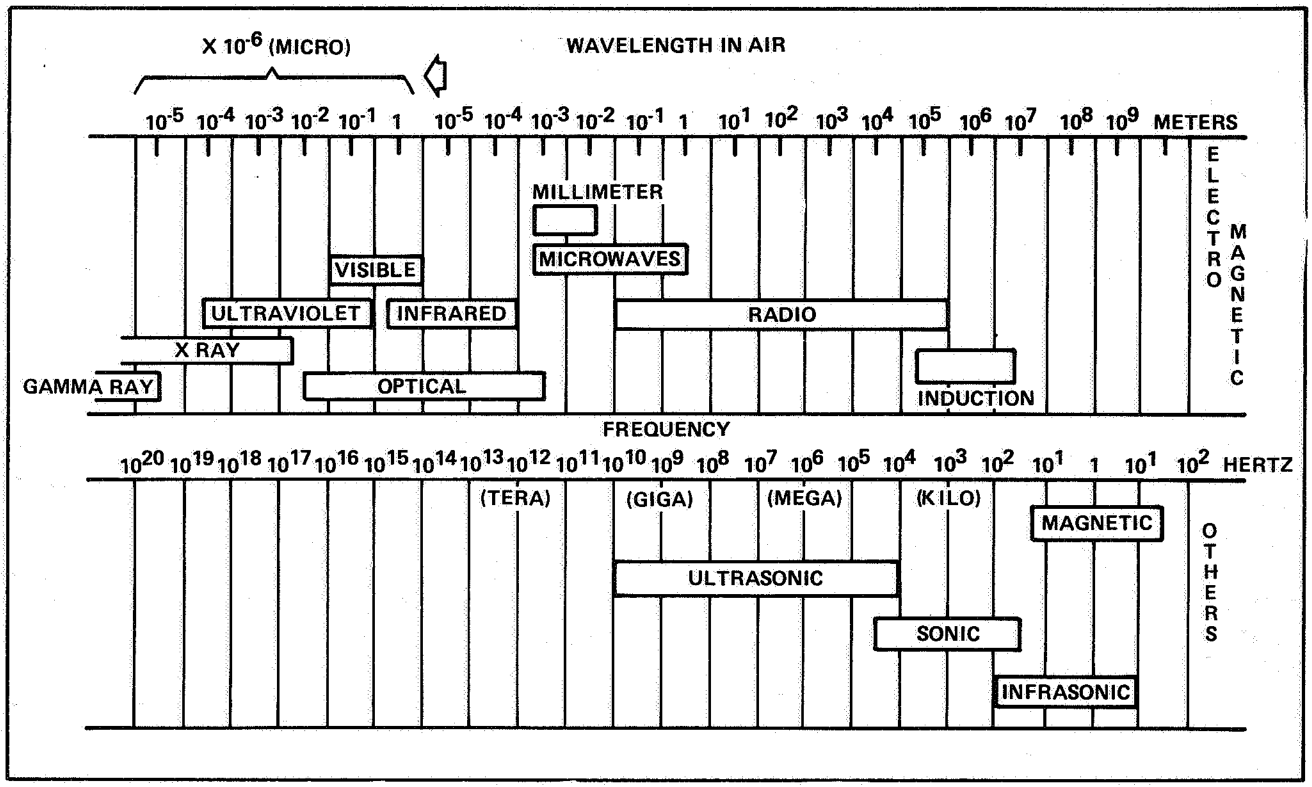

X 10^-6 (MICRO)
WAVELENGTH IN AIR
10^-5 10^-4 10^-3 10^-2 10^-1 1 10^-5 10^-4 10^-3 10^-2 10^-1 1 10^1 10^2 10^3 10^4 10^5 10^6 10^7 10^8 10^9 METERS
MILLIMETER
MICROWAVES
VISIBLE
ULTRAVIOLET
INFRARED
RADIO
X RAY
GAMMA RAY
OPTICAL
INDUCTION
ELECTRO MAGNETIC
FREQUENCY
10^20 10^19 10^18 10^17 10^16 10^15 10^14 10^13 10^12 10^11 10^10 10^9 10^8 10^7 10^6 10^5 10^4 10^3 10^2 10^1 1 10^1 10^2 HERTZ
(TERA)
(GIGA)
(MEGA)
(KILO)
MAGNETIC
ULTRASONIC
SONIC
INFRASONIC
OTHERS

Figure 14-1. The Frequency-Wavelength Spectrum

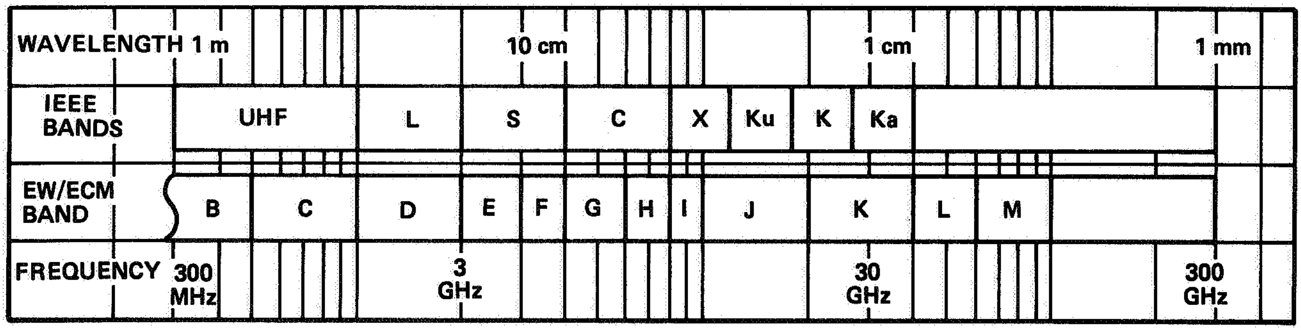


Figure 14-2. Microwave Frequency Spectrum and Bands

that is carried either by the aircraft for self-protection or by another special purpose aircraft in a support role. In most combat situations, combinations of these concepts are used to degrade more than one aspect of the total air defense system.

14.2 NOISE JAMMERS AND DECEIVERS

One of the most important countermeasure procedures to be considered in the planning phase of any amphibious/helicopterborne assault is the use of either onboard or standoff electronic equipment to detect and counter the signals from hostile radar installations. Onboard radiation emission equipment is usually referred to as a self-protection jammer (i.e., the Navy's proposed ASPJ). Off-board equipment can be carried either by a decoy or by a special purpose ECM support aircraft (i.e., the Navy's EA-6 and the Air Force's EF-111 aircraft).

There are two major radiation emission techniques used to reduce the susceptibility of the aircraft; they are noise or denial jamming and deception. Noise jamming is usually thought of as a *brute force* method in which the jammer simply *out-shouts* the echo from the aircraft. Deception techniques are more subtle (and complex) than noise jammers because they transmit signals designed to fool or confuse the radar operator by appearing on the radar screen as false targets. Deceivers are often referred to as deception jammers (which is incorrect since they don't jam) or as deception repeaters or spoofers.

14.2.1 Noise Jamming. There are several techniques used by noise jammers to obscure the aircraft echo. One is called broadband or barrage jamming. It consists of jamming a spectrum of frequencies wider than the operating bandwidth of the radar, and it may cover the operating frequencies of more than one radar system within a given band (i.e., E-band or G-band).

Spot jamming is noise jamming of a narrow frequency band located within the operating band of the radar. Swept jamming is the rapid sweeping of the noise across the range of frequenceis to be jammed.

14.2.1.1 Jamming-to-Signal Ratio. One of the most important parameters affecting the effectiveness of noise jamming is the jamming-to-signal ratio. This is the ratio of the power of the noise to the power of the echo.

Figure 14-3 shows the geometry of the jamming problem and the relationships between the jamming signal J and radar echo S from the target back to the radar; where P_r is the power of the radar transmitter, G_r is the gain of the radar transmitting antenna, R is the distance from the transmitter to the aircraft and σ is the radar cross-section of the aircraft.

The power of the jammer is usually expressed as the product of the power per unit bandwidth P_j times the bandwidth of the radar receiver B. For a variety of reasons, the frequency bandwidth of the jammer is usually larger than that of the radar; therefore, the product P_jB gives only that portion of the total jammer power intercepted by the radar receiver. The power of the noise at the target J is therefore given by $J = P_j B G_j$, where G_j is the gain of the jammer antenna in the direction of the radar receiver. (Some onboard jamming antennas are designed to have a very wide beam width so the jamming signal will not change significantly during maneuvers.) The power in the echo at the target is $S = (P_r G_r \sigma)/(4\pi R^2)$.

It is important to note that both the reflected echo and the jamming signal travel over the same range toward the receiver. Thus, the jam-to-signal ratio J/S is established at the target and remains constant all the way back to the radar. This ratio is given by the following, where P_r and G_r are the power of the radar:

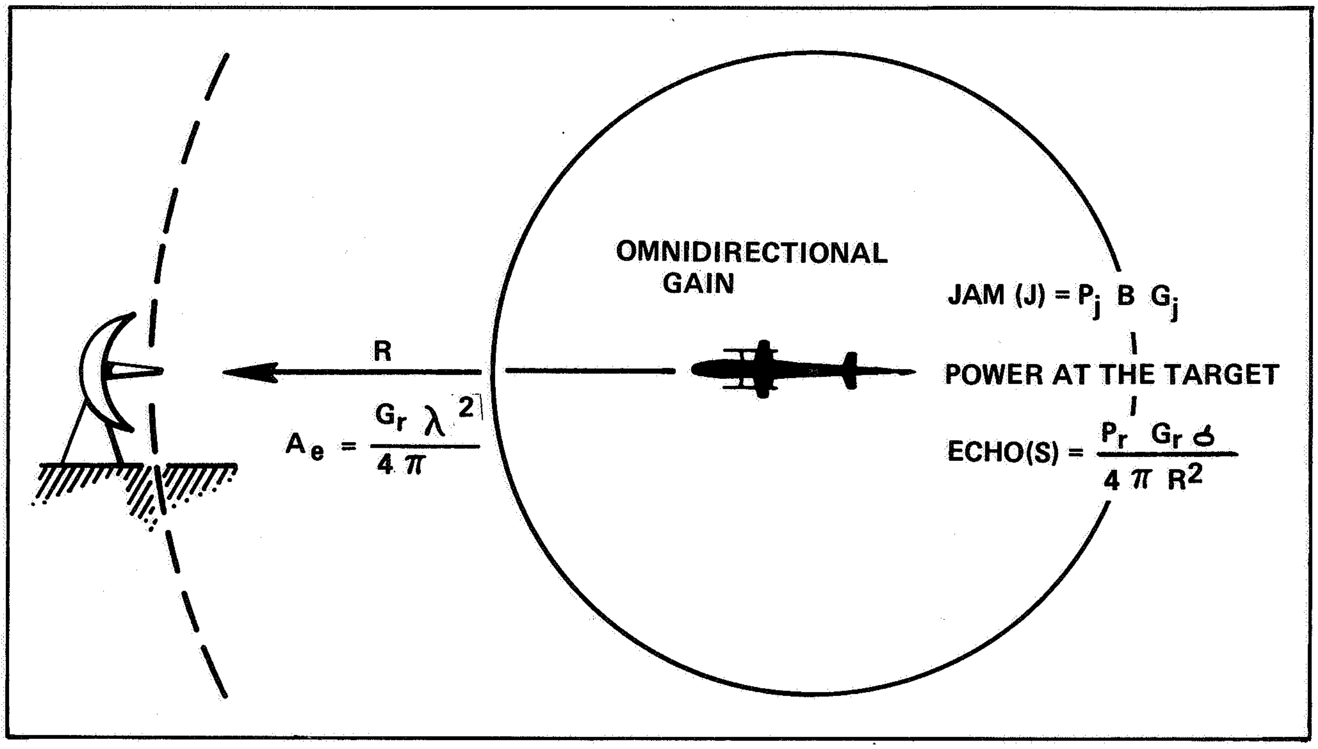

OMNIDIRECTIONAL GAIN
JAM (J) = P_j B G_j
POWER AT THE TARGET
R
$A_e = \frac{G_r \lambda^2}{4\pi}$
ECHO(S) = $\frac{P_r G_r \sigma}{4\pi R^2}$

Figure 14-3. Jamming-To-Signal Ratio

$$\frac{J}{S} = \frac{(P_j\ B\ G_j)}{(P_r\ G_r)\ (1/4\pi\ R^2)\ (\sigma)}$$

or

$$\frac{J}{S} = \left(\frac{P_j\ B\ G_j}{P_r\ G_r}\right)\left(\frac{4\pi}{\sigma}\right)R^2$$

The above equation gives some insight into the significance of the parameters of the noise jamming problem. For instance, since the J/S ratio is inversely proportional to the radar cross section, if the radar cross section is reduced by 50, with an equal reduction in jammer power, the same jam-to-signal ratio can still be maintained.

14.2.1.2 Burn-Through Range. The jam-to-signal equation gives some additional information. For example, note that the ratio is proportional to R squared. This means the jammer has a range advantage because the radar signal has to traverse twice the distance traveled by the jam signal. The echo power increases as the target approaches the radar receiver to a point where the target can be detected by the radar operator as a missile. This distance is called the *burn-through* range R_B, because inside this range, the echo is so great that the target will be visible even though the jammer is operating. Define the *camouflage factor* C as the minimum J/S ratio that will still conceal the echo in the noise, then substitute "C" in the jam-to-signal equation for J/S, and solve for the burn-through range (the burn-through range is continually changing in any scenario due to rapid fluctuations in G_j and σ) by the following:

$$R_B = \sqrt{\frac{Pr\ Gr\ \sigma\ C}{Pj\ B\ Gj\ 4}}$$

Note that the burn-through range is proportional to the square root of the radar cross section. Thus, a 50-percent reduction in radar cross section reduces the burn-through range by approximately 30 percent.

14.2.1.3 Standoff Jamming. Frequently, jammers are carried on escort aircraft rather than on the aircraft to be protected. The escort aircraft in this case frequently stands off at a distance from the target, out of range of the target defenses. There are several advantages in the use of dedicated standoff jammers compared to self-protection jammers:

1. A dedicated jammer can protect several attack vehicles.

2. A dedicated jammer can carry higher jamming power.

3. A dedicated jammer may be able to use one or more directional antennas.

4. A dedicated jammer may be able to operate at optimum altitude to maximize the jammer-to-radar propagation factor.

5. Use of standoff jammers precludes the use of home-on-jam missiles against the attack vehicles or high-value targets.

6. Two or more jammers can sometimes be used for maximum protection.

7. The precise direction to the attack vehicles is not revealed before burn-through.

Disadvantages in the use of standoff jammers are:

1. Radar-to-jammer range is relatively large, hence, high jamming power is required.

2. It may be difficult for the standoff jammer to provide maximum protection by remaining behind the strike aircraft.

The jam-to-signal ratio and burn-through range equation for the standoff jammer can be derived in a manner similar to that used for the self-protection jammer, except the ratio must be computed at the radar receiver since the jammer and the target are not coincident. This gives:

$$\frac{J}{S} = \frac{4\pi\ Pj\ B\ Gjr\ Grj\ Rt^4}{Pr\ Gr^2\ \sigma\ Rj^2}$$

and

$$R_t = \sqrt[4]{\frac{Pr\ Gr^2\ C\ \sigma\ Rj^2}{4\pi\ Pj\ B\ Gjr\ Grj}}$$

R_t is the radar to target range; R_j is the radar to jammer range; G_{jr} is the gain of the jammer antenna toward the radar; and G_{rj} is the gain of the radar antenna in the direction of the jammer. Note that if the radar receiver antenna is pointed at the target and the beam is very narrow with small side lobes, the gain of the antenna in the direction of the jammer may be small.

14.2.1.4 Operational Considerations. Maximum jammer power output may be limited by ratings of available devices, by power supply limitations on the vehicle, by safety considerations for personnel, or by power limitations of waveguides, antennas, or other components. To maximize power per unit bandwidth, the bandwidth should be made as narrow as possible and the spectrum matched to the victim receiver. In most cases, the jammer bandwidth must be greater than the receiver bandwidth to allow for frequency set-on tolerances, drift of jammer or receiver, or in order to jam several receivers on different frequencies simultaneously. Normally, the jammer obtains as uniform a jamming spectrum over the jammer bandwidth as possible so that jamming effectiveness will not be a function of the location of the receiver within the spectrum. With CW radars, it is possible to employ a modulated repeater that automatically centers the spectrum on the victim receiver and with very nearly optimum bandwidth.

To obtain antenna gain greater than unity toward the receiver, it is necessary to employ a directional antenna. If either the jammer or the receiver is moving, the antenna beam must then be steered. This may be accomplished manually if personnel are available, or may be accomplished automatically as with retrodirective antenna systems used with some repeaters.

If the characteristics of the radar receiver were known exactly, it would be possible to select an optimum waveform to use against that receiver. Such an optimum choice generally is not possible for several reasons. The victim receiver characteristics generally are not known exactly, for one thing. Even if they were, the enemy would probably change the receiver circuitry (i.e., install an electronic counter-countermeasure) to reduce the effectiveness of the jamming signal. Moreover, the jammer must usually be able to operate against several systems with receivers having different characteristics; sometimes two or more systems must be jammed simultaneously. An important factor of a radar noise jammer is to be able to select a waveform that will:

1. Produce a response in the victim receiver similar to its response to white guassian noise.

2. Have a reasonably flat spectrum within the band to be jammed. Often it is desirable to be able to adjust the width of the jamming spectrum.

There are, of course, other problems in a jamming system. The enemy radar signals must be detected and identified before they can be jammed. A jamming system is useless unless the user knows which frequencies need to be jammed. Intelligence information is not enough, for radars can change frequency or go off the air. It would be pointless to jam a radar that was not radiating. Although a nonradiating radar cannot directly measure the range to a target, it can determine the direction to a jammer. Two such radars can obtain a fix on the jammer.

Detecting radar signals while jamming presents a serious problem. The received radar signal may be in the order of -35 dBm, while the jammer output may be +55 dBm or more. Thus, isolation between jamming transmitter and ESM receiver, in the order of 90 dB or more, is required for look-though jamming detection of the victim signal while jamming. It is not always possible to obtain this degree of isolation, particularly with an omnidirectional transmitting antenna. An alternate solution to the look-through problem is to turn the jammer off for a very short time.

Threat priorities must be established in order to jam effectively. Electronic warfare support measures (ESM) are therefore needed to obtain up-to-date information on operating radars so that the most dangerous threats can be jammed. The jammer must be set on the radar frequency and jamming initiated *at the proper time*. It has been previously shown that the J/S ratio increases as the square of the range. Therefore, the jammer can be detected at ranges much greater than the range at which the jamming aircraft can be detected. The jammer should not be turned on beyond the maximum detection range of the radar. To do so gives the enemy free information he could not obtain with the radar at that range; the direction of the jammer. Another problem in the system is to provide a look-through capability, the ability to detect the presence of the radar while simultaneously jamming it. There is no point to jamming a channel if the radar has shut down or moved to a different frequency. Again, unnecessary jamming can supply free information for an enemy or serve as a beacon for a home-on-jam missile.

Sometimes when a very wide band of frequencies must be jammed, a swept jammer is used. In this case, the jamming is swept over the band of frequencies at a relatively slow rate so that each radar is jammed intermittently. The skin echo is seen intermittently, but the blip-scan ratio is reduced below its values without any jamming. It is also more difficult to determine the direction to the jammer from the radar PPI display, since jamming strobes appear on the display in various directions, depending on the radar antenna pointing direction at the times when the jammer passes through the radar receiver passband. Strobes tend to be strongest in the general direction of the jammer.

All forms of noise jamming are generally most effective if several jammers are scattered geographically and used simultaneously. With several jammers in different directions, the scope picture can be so confused that it is difficult to determine the direction to any one of the jammers. This is particularly true at short to moderate ranges where the jamming may enter the radar antenna through both mainlobes and sidelobes.

14.2.2 Deception. Deception (DECM) of a surveillance or weapon control radar system consists of those electronic techniques that present false target information to the radar. In some cases, it may be possible to cause the break-lock of the tracking radar, causing it to become completely unlocked from the target. The radar must then attempt to reacquire the aircraft. The usual approaches are to:

1. Generate a large number of false targets that are indistinguishable from the real target and that overload the system by subtle means rather than by brute force.

2. Provide incorrect target bearing and/or range information to the radar.

In general, deception signals can readily be unmasked by a properly designed radar, but they are very effective if not accounted for by the radar.

The identifying characteristics of a deception signal are:

1. Simulated echoes appearing either earlier or later than the target echo from the aircraft carrying the deceiver.

2. If more than one simulated echo appears within the same radar pulse repetition interval, they will all lie in the same direction.

3. Simulated trajectories will not always appear realistic or threatening.

4. Artificial echoes will usually not have an echo power that is linearly related to the transmitted power.

14.2.2.1 Deception Techniques. There are many deception techniques available today, and many more will probably be developed to counter the changing threat environment. The basic DECM methods can be divided into four categories according to the type of echo modulation used: time, amplitude, phase or frequency, and polarization. Figure 14-4 presents some of the specific techniques developed under each of these categories.

14.2.2.2 Comparison of Noise Jammers and Deceivers. The noise jammer is universal in that it can degrade the performance of any radar. With adequate noise, range information is denied to the pulsed radar. Relatively high power is required for noise jammers since they

TIME MODULATION DECM
- Range-Gate Pull-OFF
- Multiple False Targets

AMPLITUDE MODULATION DECM
- Countdown
- Cover Pulse
- Scan-Rate Modulation
  - Inverse Antenna Modulation
  - Inverse Conscan
  - Cross-Pattern Modulation
  - Lobe Shifting
  - Swept Amplitude Modulation
- False Target by Reflection

PHASE OR FREQUENCY MODULATION DECM
- Velocity-Gate Pull-Off
- Pulse-Compression Deception
- Superheterodyne Jamming
  - Image-Frequency Jamming
  - Dual-Frequency Jamming
  - Skirt-Frequency Jamming
- Cross-eye

POLARIZATION MODULATION
- Cross-Polarized Jamming

Figure 14-4. Basic DECM Techniques

generally operate with a 100-percent duty cycle. Directional information is not denied by a single jammer used for self-protection. The noise jammer can serve as a beacon for a homing system including home-on-jam missiles. Jammers on each of several vehicles can provide mutual protection, denying good directional information on any vehicle.

The deceiver for a pulse radar usually requires relatively small average power output since its duty cycle is comparable to the radar duty cycle. To be effective, its modulation must be carefully tailored to the characteristics of the victim radar. Like the noise jammer, the deceiver can serve as a beacon although it is somewhat harder to detect. It can be programmed to give false range information and false angular information against scanning radars. Angular deception against certain types of direction finders is much more difficult. The wide bandwidths, high gain antennas, and long observation time of weapon-control radars make them less susceptible to noise jamming, and consequently, deception is more likely to be effective.

14.2.3 Fuze Jamming. Many modern missiles are detonated by some sort of proximity fuze which senses the presence of the target and explodes the warhead at optimum distance to maximize damage. Proximity fuzes can sometimes be affected by countermeasures. The best countermeasure procedure, in general, will cause the fuze to predetonate the warhead at a range great enough to reduce the probability of damage to the target to near zero. When this is not possible, an alternate countermeasure mode is to prevent operation of the proximity fuze. This is of little comfort if the missile scores a direct hit and has a back-up contact fuze.

14.2.3.1 Fuze Types. Some fuze types and their modes of operation are listed in Figure 14-5. Earliest fuzes generally used superregenerative detectors. The superregenerative detector employs an oscillator which is quenched periodically, either through blocking in the circuit (self-quenched) or by an external ac source (separately quenched). In the absence of a received signal, oscillations build up from circuit noise. With a signal present, the oscillations build up sooner and the average current in the device (typically) increases. If the detector is connected to an antenna, signals reflected from a nearby object cause an increase in average current; so, an increase in current is an indication that the detector is approaching a reflecting object.

The chief disadvantage of the superregenerative detector for a proximity fuze is that it is actuated at greater distances by large objects than by small objects, and at greater distances for objects with high-radar cross section than for objects of low-radar cross section.

FUZE TYPE	MODES OF OPERATION
Superregenerative	Amplitude of signal return
Pulse	Range
CW	Velocity
FMCW	Range and/or velocity
Pulse Doppler	Range and/or velocity
Noise (including pseudo-random biphase modulation)	Range and/or velocity

Figure 14-5. Types of Proximity Fuzes

It is relatively easy to use a repeater to cause predetonation of a superregenerative fuze.

Pulse fuzes are miniature, short-range, pulse radars that measure the range to the nearest object in the antenna beam. Shaped beams are sometimes used to reduce the sensitivity in some directions relative to that in preferred directions.

CW fuzes measure relative velocity of missile and target. The Doppler shift drops to zero at the point of closest approach. The fuze may be set to trigger just before the Doppler shift drops to zero for reasons to be discussed shortly.

FMCW, pulse Doppler, and noise fuzes may operate on range or velocity, or a combination of the two. Multimode operation is a common fuze counter-countermeasure to make it more difficult to use deceptive signals to predetonate the fuze.

14.2.3.2 Low-Altitude Fuzes. A special problem arises when a fuze is designed to operate at a fixed range from the target when the missile must operate at low altitude. With no special provision to prevent it, the fuze would operate on the strong ground return signal as soon as the altitude reduced to a value equal to the maximum designed detonation range. One solution to this problem is to detect the very strong altitude return and to desensitize the fuze at the range and all greater ranges. The range at detonation must then be less than the missile altitude.

14.2.3.3 Doppler Fuzes. Most warheads throw the bulk of the fragments released in the explosion in a cone in the forward direction. This is accomplished, in part, by appropriate shaping of the explosive and the associated shrapnel, and is, in part, due to the forward motion of the projectile. Concentration of the fragments increases the lethality of the missile, provided the cone of concentration intercepts the target. With large miss distances, the Doppler frequency difference decreases gradually as the relative range parallel to the trajectory decreases. The Doppler frequency drops abruptly when the miss distance is small. If the fuze is set to operate at a fixed value of Doppler shift, then for given fixed missile and target velocities, the angle between the trajectory and the direction to the target at detonation can easily be shown to be independent of miss distance. Unfortunately, for a given Doppler shift, the angle increases as the relative velocity increases. Thus, the warhead will explode at a long distance (small angle) from a receding (low relative velocity) target, but at a short range (large angle) for an approaching (high relative velocity) target. If the missile speed is much, much greater than target speed, these effects are relatively small.

14.2.3.4 Countermeasures. A fuze that operates on amplitude of return may be predetonated by a repeater that increases the amplitude of the returned signal. Kill probability is further reduced if the repeater is located in a vehicle well to the side of the missile trajectory.

To predetonate a fuze that operates on target range, target range shorter than actual range must be simulated. Against pulse fuze, this can be done by inbound range gate pull off. This technique cannot work when the radar pulse period has signficant pulse-to-pulse jitter. A different technique would be required to deceive the range-measuring circuits of an FMCW fuze.

In the case of a Doppler fuze, the particular Doppler shift that will trigger the fuze must be simulated. It may be possible to successfully do this by modulating a repeater with, for example, one variable or several fixed frequencies.

Another technique, serrodyne modulation, is capable of shifting the output frequency of a repeater by predetermined amount, either up or down. This technique is usually employed with a traveling wave tube and is accomplished by continuously shifting the phase of the signal by changing the beam voltage. Serrodyne modulation, properly done, produces one dominant frequency component in the output with little energy at the carrier and other sideband frequencies. Whether one or several frequency components will be more effective in jamming a Doppler fuze depends on the fuze circuit details.

14.2.3.5 Fuze Counter-Countermeasures. Probably the oldest fuze ECCM is the use of the controlled-variable-time (CVT) technique, a technique that is just about universally employed with proximity fuzes. With CVT, the fuze is not armed until it reaches the target vicinity. With many fuzes, this is necessary to keep the fuze from triggering on signals returned from objects in the vicinity of the launcher, or from the launcher itself. The fuze may be armed after a preset time, or may be armed by a command radio signal. In the latter case, the radio link itself is subject to jamming. With CVT, countermeasures applied before the fuze is armed have no effect. Much less time is available for the countermeasure to find the key to the fuze operation and to be effective.

Fuzes in general operate over a very wide band of frequencies from VHF up. If a given missile type can be equipped with fuzes operating over a wide frequency range, this increases the difficulty of jamming the fuzes. Since fuzes generally need to operate only at very short ranges, they have very low power output, thus increasing the difficulty of picking up their signals.

Many fuzes employ multimode operation. The signals from two or more modes are required to be consistent in order to trigger the fuze. Consider, for example, a Doppler fuze operating at 1 and 3 GHz. The Doppler shift at the latter frequency will be three times that at the lower frequency. A countermeasure, to be effective, must simulate the Doppler shift at both carrier frequencies, and must do so in the correct ratio.

Another possibility for multimode operation is a fuze such as an FMCW fuze that measures both range and range rate. The range rate may be determined by measuring range-versus-time, as well as from the observed Doppler shift. The fuze is triggered only if the two measurements are consistent.

In recent years, some very sophisticated fuzes have evolved that make it very difficult to deceive or saturate the fuzes. The decoy remains the only effective countermeasure against these fuzes, but is not always a practical solution. When fuze jamming cannot be employed, other protective measures must be used (i.e., jamming of the guidance system or evading the missile).

14.3 SIGNATURE SUPPRESSION

The ability of a threat system to successfully detect, locate, identify, and track an airborne target was described as having a signficant influence upon the survivability of the target. Design features that reduce the efficiency with which a threat system can accomplish these functions are, therefore, extremely important. There are several observable or detectable parameters utilized by threat systems for target detection; they are: (1)

electromagnetic reflection, (2) thermal or infrared radiation, (3) optical, and (4) acoustic. Each observable parameter contributes a unique set of characteristics that make up the aircraft signature. Signatures are categorized as radar, visual, aural, and infrared (IR) according to the general methods of detection employed by the threat systems. The method of detection used is typically a function of the sophistication of the threat system as indicated in (Figure 14-6).

The general methods used to reduce or degrade a threat system's ability to detect, locate, identify, and track a target are:

1. Reduction of the target signature to levels that are below the sensor threshold
2. Masking of target signatures by minimizing target to background contrast
3. Degradation of the threat system sensors
4. Masking or biasing of the target signature to create threat system sensor errors.

THREAT SYSTEM	TYPICAL DETECTION METHODS
Small Arms thru 14.5 mm	Visual, aural
Antiaircraft guns 20 mm thru 100 mm	Visual, aural, radar
Air-to-air guns (AAG)	Visual, Radar
Air-to-air rockets (AAR)	Visual, radar
Air-to-air missiles (AAM)	Radar, IR
Surface-to-air missiles (SAM)	Radar, IR

Figure 14-6. Threat Detection

The particular methods used to enhance survivability depend on the type of threat system sensors expected to be encountered.

14.3.1 Radar Signature

14.3.1.1 Description. Ground-based and airborne radar systems are used to provide a wide variety of weapon system functions including search, acquisition, tracking, fire control, guidance, and fuzing. All of these systems employ the principle of radio-frequency electromagnetic energy that is emitted in a specific frequency band from a transmitter, reflected from a target, and then intercepted by a receiver. The transmitted and received signals are compared, and a target location and velocity are obtained.

The parameter that describes the number of radar signals reflected from a target is called the radar cross section (RCS). It is a function of the size and shape of the target, the electromagnetic properties (permittivity, permeability, and conductivity) of the materials from which it is made, the radar signal frequency, and the orientation of the target with respect to the radar (i.e., the viewing angle). For many targets, the RCS is smaller than the physical cross section because the target may absorb part of the incident radar energy, or it may reflect part of the energy in a direction away from the radar receiver, thus depriving the receiver of much of the echo. Other types of targets exhibit RCS levels considerably larger than their physical cross sections due to a focusing effect of the reflected energy in the direction of the receiver.

The size of the target RCS impacts the performance of radar in several ways, but the most important effect is the establishment of a maximum range limitation. In very simple terms, a target with a large RCS is easy for the radar to *see*, even at long ranges. If the target RCS is small, however, it must be much closer for the radar to *see* it. The RCS level also influences the effectiveness of jamming techniques employed by the target.

Because of the varied roles of radar in modern electronic warfare, many different types of radar systems may be encountered by an aircraft. Generally, the most serious radar threats are those associated directly with fire control of attack ordnance (i.e., surface-to-air and air-to-air missiles, and antiaircraft artillery). The mission requirements determine the specific radars and their frequency bands that may be encountered and what detectability levels can be tolerated. For example, tactical aircraft, such as a fighter-bomber, would not be used against a foreign force except during overt warfare. As a consequence, knowledge of its presence by the enemy may not reduce its mission effectiveness. A covert reconnaissance vehicle, on the other hand, must perform its mission without detection, and hence, all radars must be considered threats. Furthermore, while the use of active ECM may be a viable protective alternative for the fighter-bomber, a jamming signal would surely betray the presence of the reconnaissance vehicle. This makes passive protection the only possible protection for such a vehicle.

14.3.1.2 Suppression Techniques. The two parameters that determine the RCS of any target are its geometry (size and shape) and the electromagnetic properties of the aircraft materials. Materials with very high conductivity are the strongest reflectors, while materials with low conductivity will tend to either transmit or absorb incident microwave energy. In the consideration or the geometry, shape is usually a more signficant determinant of RCS level than size. Energy incident on a flat metallic surface such as a wing or fuselage side will tend to be reflected away from the source in mirrior-like fashion for all angles of incidence, except the angle perpendicular to the surface, thereby contributing to the radar echo only over a very small range of aspect angles. Metallic, cavity-shaped structures, on the other hand, tend to behave like "corner reflectors" which tend to reflect all, or nearly all, of the energy entering the cavity back toward the source. Metallic, cavity-shaped structures, such as engine inlets and exhaust systems, therefore tend to be major RCS contributors over wide ranges of viewing angles. Regions of very high reflection are often called *echo sources* or *flare spots*.

Since the RCS of any target is determined by its geometry and its material properties, the key to radar signature reduction is the exploitation of low-reflection geometries and materials or coatings with controlled electromagnetic properties. The most difficult reflective area to reduce has been the engine exhaust system cavity. The difficulty arises from: (1) the fact that flexibility in geometrical configuration is often limited, and (2) the limited number of materials and coatings available with controllable electromagnetic properties that are capable of withstanding the high temperature, thermal shock, pressure, and chemical environment of a modern turbine engine exhaust system. The geometry of the exhaust cavity, which has the greatest effect of RCS, is determined primarily by the selection of the engine thermodynamic cycle and nozzle type. Surface geometries that do not attenuate the reflected signal and hence should be avoided are: (1) large, flat surfaces that are normal to the impinging signal, (2) surface intersections that form into concavities or reflectors, and (3) cavity-type configurations that intercept smooth surfaces and contain internal reflection surfaces.

14.3.2 Infrared Signature

14.3.2.1 Description. All aircraft emit and reflect IR energy. The amount of IR radiation emitted by an aircraft is strongly dependent upon the surface temperature and, to a lesser degree, on the surface emissivity and area. The dominant IR contributors over the aft hemisphere of the aircraft are the hot engine exhaust surfaces. Radiation from the engine exhaust gases and from the airframe surfaces are the principal contributors over the side and frontal hemispheres. The airframe reflection of the sun's radiation and the Earth's radiation is usually the dominant IR reflective sources over the side and bottom hemispheres. Reflective radiation during daylight operations is very strong and may approach the level of surface emissions.

14.3.2.2 Suppression Techniques. IR suppression techniques reduce the level of infrared radiation, either over a given viewing zone or over all viewing zones. By reducing the angular extent of the highly IR radiant zones (for example from ±90° to tail-on to ±20° to tail-on) the threat is forced to come in closer to tail-on to the target aircraft. This signature shaping can be accomplished by utilizing techniques such as engine tailpipe and nozzle cooling, which leaves only the hot turbine and exhaust centerbody as the major IR contributors.

Engine hot parts emissions can be reduced by further cooling of the engine exhaust system hot components with cooler ambient air or, in the case of turbofan engines, with bypass air. Engine exhaust system components that may be cooled are the exhaust frame centerbody, flameholders, tailpipe, and nozzle walls. Cooling air may be pumped by external blowers or ejectors in the case of turboshaft engines; or, for turbofan engines, from the fan flow. The cooling air is generally applied to the surface through cooling slots which combine impingement and convective cooling.

For components which remain hot, such as turbine blades, cooled shields which block the view of the blades to the threat are used. Another method of shielding the blades from view is to incorporate a turn in the exhaust duct. Further IR radiation reduction may then be accomplished by coating the cooled surfaces with IR radiation absorbent materials. These materials ideally should be diffuse reflectors which return half of the radiation toward the turbine, and reflect little of the remaining portion in the direction of the exhaust exit plane. In this way, the radiation is forced to have a larger number of reflections from the absorbing materials and thus a higher probability of absorption before leaving the exhaust duct.

Supression of engine exhaust plume IR radiation levels is most efficiently performed by reducing the gas temperature, either before it leaves the exhaust system or as soon thereafter as possible. One technique used on turbofan engines, which have a hot gas generator or core stream and a much cooler bypass or fan airstream, is to employ a mixer to bring the hot and cool streams into contact just downstream of the turbine discharge plane. This forces these gases to mix in a constant or decreasing cross-sectional area duct prior to exit from the nozzle.

Plume IR reduction can be obtained under flight conditions by turning the exhaust gas at an angle to the flight direction which effectively puts the plume in a cross flow. This cross flow, depending on the momentum of the ambient air cross flow relative to that of the plume, will cause rapid mixing of the ambient air with the plume and turn the exhaust gas stream into the direction of the cross flow. With helicopters, such a rapid decay of the exhaust temperature occurs that the exhaust gas core disappears within several diameters downstream of the exit plane and, in this case, little radiation is contributed by the exhaust gas external to the exhaust duct. The major contributor to gaseous radiation is the hotter unmixed gases inside the exhaust duct. Radiation from these gases is normally absorbed by the cooler exhaust gas products downstream of the exhaust plane. However, the cross flow bends the path of the plume such that the little optical depth of the cooler exhaust-gases is available to absorb the radiation from inside the exhaust duct.

14.3.3 Visual Signature. The majority of combat aircraft lost in Southeast Asia were hit by projectiles from optically directed weapons. In many cases, the enemy aimed a barrage in the direction of the visual signatures of the aircraft before the aircraft itself could be observed. This was especially true for fixed-wing jets emitting engine smoke trails. In addition to smoke, visual signatures include contrails, and at night, exhaust glow.

When reducing visual signatures, use engines with little or no visible smoke emissions. The amount of reflective surfaces must be minimized to prevent or minimize glint. The use of flat transparencies should be considered in those military aircraft systems required to fly at low altitudes and speeds to accomplish their missions. In rotary-wing aircraft, rotor blade *flicker* detection has been found to be higher with two-blade configuations over those with four or more main rotor blades. Camouflage is an effective means of reducing visual detection by minimizing the visual contrast of the aircraft with its background. Helicopter rotor heads have also been found to be a significant source of reflected light. Consideration should be given to finishes or coatings that will minimize or subdue such reflective surfaces. Rotor blade tip markings may provide visual clues to the enemy, but elimination of such markings must be evaluated with personnel safety factors.

Standard bright identification markings and olive drab paint with a glossy finish are also reflective and are visible for a considerable distance both in sunlight and moonlight. Lusterless camouflage paint should be used for the overall aircraft, with low-contrast paints for the necessary aircraft markings. Well-chosen simple camouflage patterns are more effective than more complex patterns. Temporary camouflage coverings or paint may be used to mask those transparencies not essential for specific missions. Night time combat operations are a special case where the effects of the aircraft's interior and exterior lighting systems must be considered as major sources of potential visual clues to enemy ground forces. Exterior lights should be masked from ground angles to the greatest degree practical while providing adequate safety for formation flying. The capability of anticollision light installations to reflect moonlight or other light sources when not in operation should also be considered to minimize such occurrences. Interior instrument lighting systems must be considered as potential sources of light visible from the ground. Care should be exercised to minimize the direction and intensity of instrument lighting for combat missions and to minimize the interior reflective surfaces of the cockpit.

When viewed directly, the exhaust glow of turbine engines can be seen readily at night. For aircraft with primary missions at night, consideration should be given to probable viewing angles and methods of masking engine glow from the enemy.

14.3.4 Aural Signature. Aircraft are often heard before being seen by ground observers, primarily as a result of engine noise. Low-flying helicopters can sometimes be heard as much as 30 seconds before they become visible as a result of rotor noise. Under battlefield conditions, however, background noise from tanks, guns, and other aircraft may prevent aural detection.

Most of the approaches to noise reduction result in reducing aircraft performance to the point that the aircraft and its parts would be scarcely moving. There is, therefore, always a tradeoff between noise reduction and vehicle performance. This does not imply, however, that two vehicles with the same performance must produce equal noise. Judicious and intelligent application of noise reduction techniques, to an aircraft that does not require high performance, results in a surprisingly low noise level. Engine noise may be reduced by acoustically treating the fan inlet and the engine exhaust duct. Combustor and turbine noise may be reduced by the use of acoustic treatment just down-stream of the low pressure turbine.

CHAPTER 15

Electronic Warfare Equipment

15.1 INTRODUCTION

This chapter is an unclassified presentation of helicopter EW equipment. It will cover a description, the operating instructions and information on the AN/APR-39(V)1 radar warning receiver, AN/ALE-39 countermeasures dispensing set, and the AN/ALQ-144 infrared jammer. Mention will also be made of advanced EW equipment items. See Figure 15-1 for EW equipment component locations. Refer to Chapters 19 and 21, NWP 55-9-ASH, Vol. II (Rev. C).

15.2 ELECTRONIC WARFARE EQUIPMENT

The electronic warfare equipment is designed to make the helicopter more survivable in the threat environment, whether low threat or high threat. The equipment on any helicopter has a definite interaction, whether or not the equipment is physically or electrically connected. The interaction of the equipment is directly related to the action and employment of the helicopter and its equipment by the pilot. Tactical employment still depends on sound tactics to survive in a threat environment but will not protect a helicopter if it is not employed in a sound tactical manner. The best countermeasure in a high-threat environment is denial of acquisition to the enemy, and this is best accomplished by terrain flight profiles.

15.3 AN/APR-39(V)1 RADAR WARNING RECEIVER

The APR-39 provides the helicopter aircrew with bearing, identity, and mode of operation of radars which operate in E, F, G, H, I, and J bands and portions of C and D bands for radar associated signals. A CRT displays strobes and audio-proportioned PRF of signals plus alarm tones, in rear cockpit only.

15.3.1 Control and Indicators. The cockpit control unit has an ON/OFF switch for operation of the equipment, a self-test switch which activates the CRT test display and audio test tone, a discriminator switch to reduce the system sensitivity (discriminator should not be used in a tactical situation), and an audio volume control knob to adjust headset PRF volume. The cockpit display CRT has a brilliance adjustment knob to adjust intensity for daylight down to night vision goggle intensity. A polarized filter for day-night operations adjusts the color of the strobes from white to red. An MA light is located at the 10 o'clock position on the CRT. An MA cover is provided for night vision goggles operation.

15.3.2 Equipment. There are four spiral antennas mounted on the left front and right front of the nose of the helicopter and on the left rear and the right rear of the helicopter tail. A radar receiver mounted in the nose of the helicopter electrically connects the two front antennas to the comparator; a similar radar receiver is mounted in the tailboom. A blade antenna, mounted on the belly of the aircraft between the cross tubes, provides C- and D-band radar information to the comparator to activate the MA light on the CRT. The comparator provides video signals to the CRT and audio signals to the crew ICS (Figure 15-2).

15.3.3 Control and Functions. Figures 15-3 and 15-4 describe the functions of the controls for both the cockpit control unit and the radar signal indicator.

15.3.4 Operating Procedures

15.3.4.1 Turn On Procedure. The procedure for turning on the equipment follows:

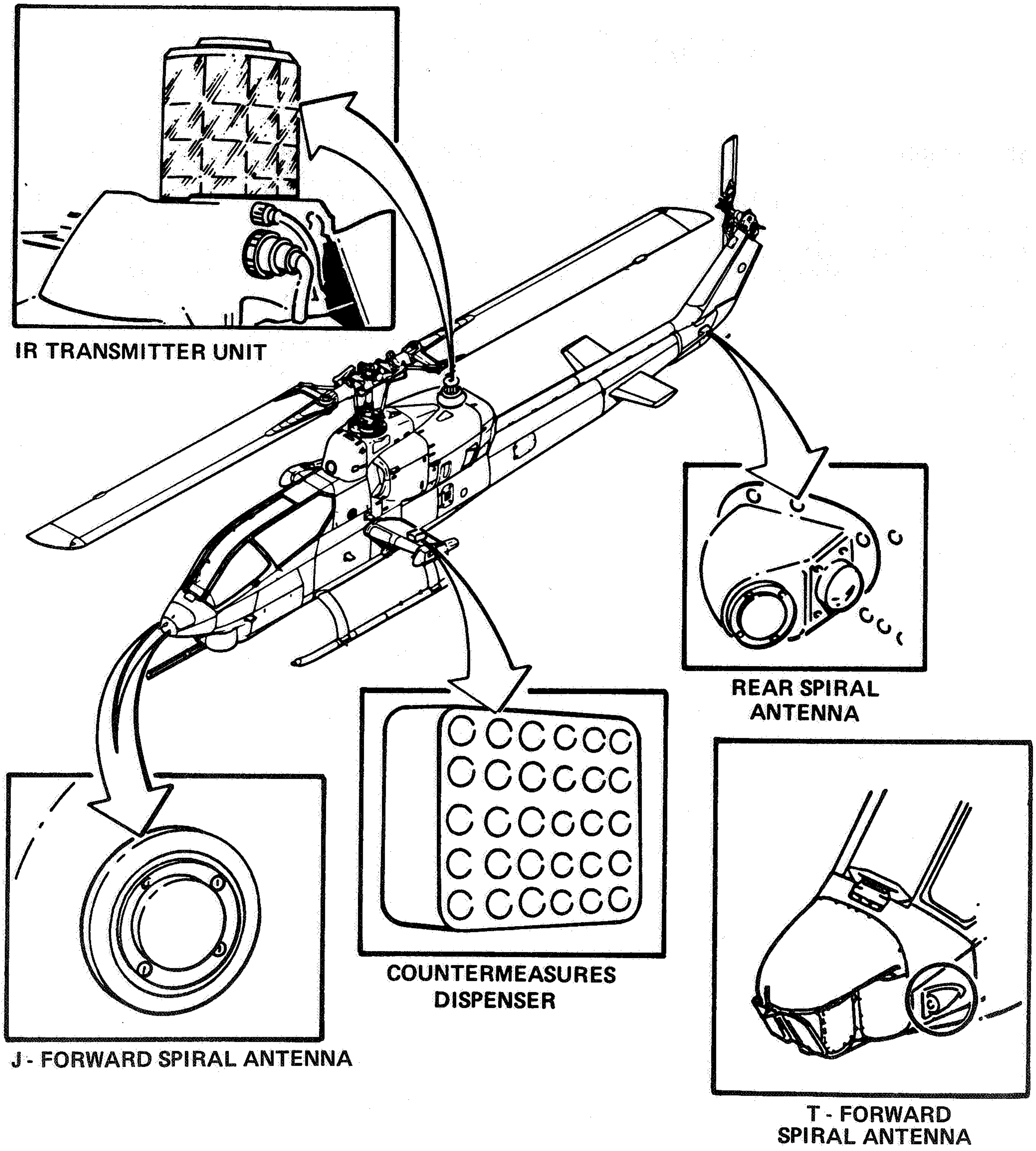

IR TRANSMITTER UNIT
REAR SPIRAL ANTENNA
COUNTERMEASURES DISPENSER
J - FORWARD SPIRAL ANTENNA
T - FORWARD SPIRAL ANTENNA

Figure 15-1. AH-1J and AH-1T Exterior Configuration

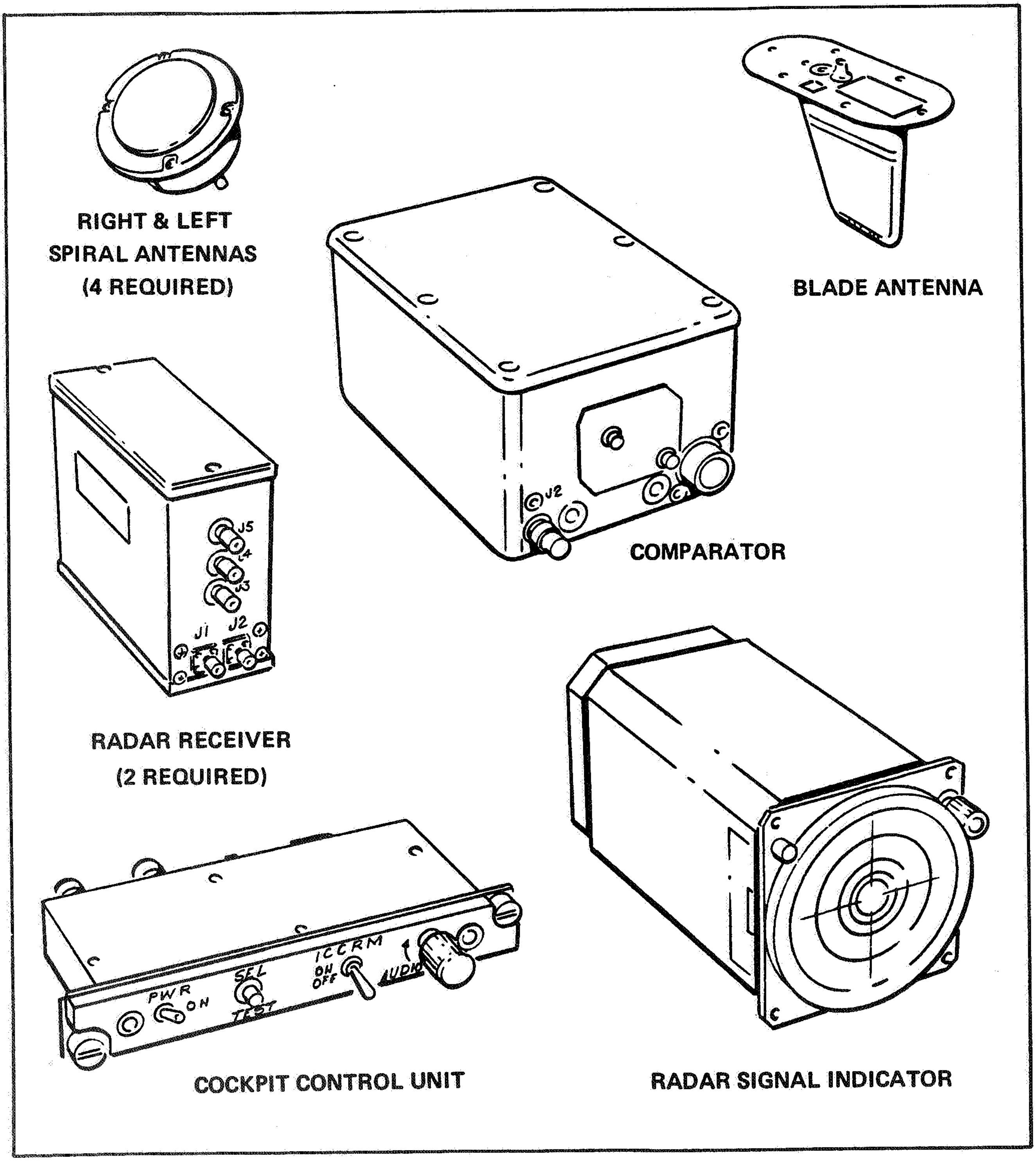
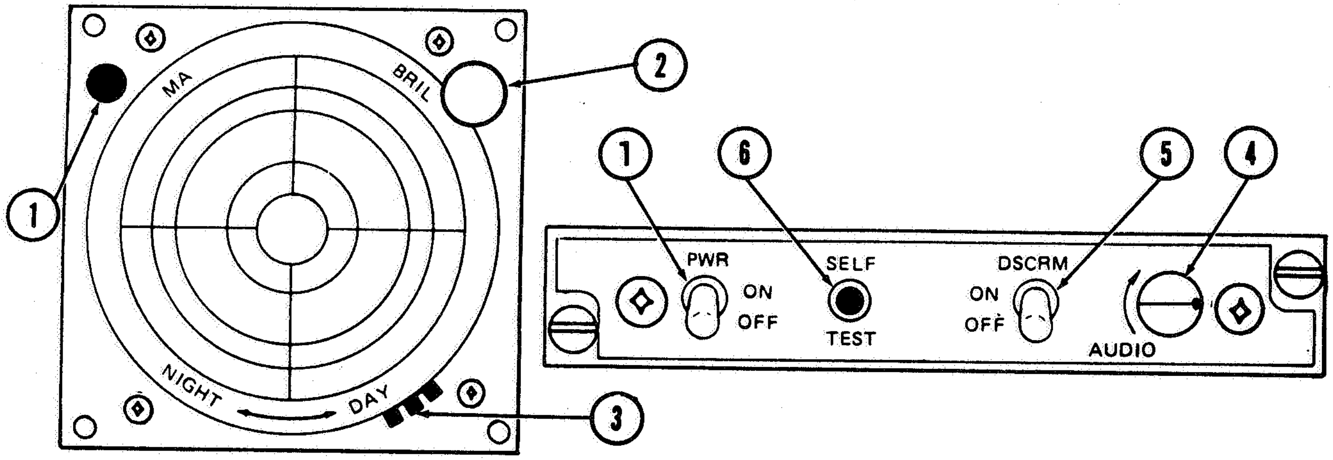


Figure 15-2. APR-39(V)1 Radar Warning Receiver Components



CONTROL/INDICATOR		
1. **MA indicator**	4. **AUDIO control**	7. **PWR switch:**
2. **BRIL control**	5. **DSCRM switch:**	
3. **NIGHT–DAY control**	6. **SELF TEST switch:**	

Figure 15-3. Radar Warning Indicator and Control AN/APR-39

CAUTION

To prevent damage to the receiver detector crystals, assure that the AN/APR-39(V)1 antennas are at least 60 yards from active ground-based radar antennas or 6 yards from active airborne radar antennas. Allow an extra margin for new, unusual, or high-powered emitters.

1. Check to see that the aircraft 28 vdc bus for the AN/APR-39(V)1 equipment in the aircraft is turned on. (Refer to applicable electronics configuration manual for the particular aircraft.)

2. Set the PWR switch (Figure 15-2) to ON, and allow a minimum of 30 seconds for the equipment to become fully operational.

3. Depress and hold the SELF TEST switch; adjust the BRIL and FILTER controls for the desired CRT display brilliance and color (maximum red for NIGHT). Adjust the AUDIO to the desired output level; release the SELF TEST switch.

4. Manipulate the DSCRM switch in accordance with mission requirements.

Note

The discrimination switch should be in the OFF position in a tactical situation.

Control Name	Description	Function
PWR	Two-position toggle switch	Controls application of aircraft +28 Vdc to the AN/APR-39(V)1. a. ON position applies operating power. The AN/APR-39(V)1 is fully operational 1 minute after switch is turned ON. b. OFF position removes operational power from AN/APR-39(V)1.
SELF-TEST	Pushbutton switch (spring loaded)	When depressed, energizes the self-test function.
DSCRM	Two-position toggle switch	Selects AN/APR-39(V)1 mode of operation. a. ON (up position) activates the discriminator circuit. b. OFF (down position) deactivates the discriminator circuit.
AUDIO	Pontentiometer	Controls the level of the audio output to the aircraft interphone control system.
Direction display	CRT display	Shows a line-of-bearing radial strobe for each processed emitter signal.
MA indicator	Lamp	Flashes on and off to indicate time correlation between the missile guidance and associated tracking radars (SAM radar complex).
BRIL control	Potentiometer	Varies the brilliance of the CRT display; used in conjunction with the filter control to produce a highly visible, unobtrusive display under most lighting conditions.
Filter control		Varies the density of the red polarizing faceplate filter (primarily for DAY or NIGHT operation).

Figure 15-4. Radar Signal Indicator, Control, and Display Functions

15.3.4.2 Operation Modes. The equipment may be operated in either the discriminator off mode or the discriminator on mode.

CAUTION

Display strobe lengths indicate only received signal amplitude. Since many variables can affect the atmospheric attenuation of the signals, strobe length should not be interpreted as being directly indicative of distance to the emitter.

15.3.4.2.1 Discriminator Off Mode. When operated in the discriminator off mode, the DSCRM switch is placed in the OFF position. In this mode all highband received signals with an amplitude greater than the predetermined threshold level are displayed on the CRT and an audio signal, representative of the combined amplitudes and pulse repetition frequencies (PRFs), is present at the headset. The displays indicate the total radar environment in which the aircraft is operating. Each radial strobe on the CRT is a line of bearing to an active emitter. When a SAM radar complex becomes a threat to the aircraft (lowband signals correlated with highband signals), the unique alarm audio is superimposed on the PRF audio signal and the MA lamp and associated strobe start flashing. Lengths of strobes and audio levels depend on the relative strength of the intercepted signals.

Note

In this mode, received lowband signals which are not correlated with a wideband intercept will cause the MA lamp to flash and an alarm audio will be present.

15.3.4.2.2 Discriminator On Mode. When operating in the discriminator on mode, the DSCRM switch is placed in the ON position. In this mode, signals are processed to determine their conformance to certain threat-associated criteria:

1. The signal level must be greater than the minimum threshold level.

2. Pulse width must be less than the maximum pulse width.

3. PRF must be greater than the minimum pulses per second (PPS).

4. The pulse train must exist with not less than minimum pulse train persistence.

5. The CRT display is divided into eight sectors. Strobes are displayed only in those sectors in which signals meeting all threat criteria are present. This reduces display clutter by eliminating low-level and width-pulse-width signals and by selective sector display. Intercepts which meet these requirements are displayed as described previously.

Note

In this mode, uncorrelated lowband signals will not give any indication.

15.3.4.3 Self-Test. The self-test confidence checks the AN/APR-39(V) 1 circuits except:

1. Antennas

2. High-pass filters and detectors in the highband receivers

3. Band-pass filter and detector in the lowband receiver section

4. Analysis signal commutator

5. High- and lowband blanking circuits

Figure 15-5 lists the procedure for the self-test.

15.3.4.4 Shutdown. The APR-39 is shut down by placing the PWR switch in the OFF position.

15.3.5 Audio and Visual Signals. Figures 15-6 through 15-9 list AN/APR-39(V)1 audio and visual signals for various Soviet-built weapon system radars.

The APR-39 will also receive and display free world radars and both Soviet and non-Soviet airborne radars. No listing of visual or audio signals of these radars is currently available.

15.4 AN/ALE-39 COUNTERMEASURES DISPENSING SET

15.4.1 Description. The AN/ALE-39 (Figure 15-10) is installed and is used to dispense countermeasures materials (metallic chaff, flares, and jammers) aft of the aircraft. The ejected countermeasures materials deceive enemy radars and infrared sensors and jam communications frequencies, which enable the aircraft to evade air-to-air and surface-to-air attacks. Each dispenser has 30 cylindrical discharge tubes, electrically partitioned into sections of 10 and 20 discharge tubes. The dispenser module sections are identified as L10 (left 10), L20 (left 20), R10 (right 10), and R20 (right 20) to distinguish payload locations and controlling circuits. The cartridges containing the countermeasures materials are carried in the discharge tubes of the two dispensers. After the dispensers are loaded, the pilot or ground personnel set the programmer LOAD switches to indicate which type of load is in each of the

1 Apply power to AN/APR-39 (see applicable aircraft manual).	Control unit panel lamps come on.

Note

In well-lighted areas it may be necessary to shade the panel to determine whether panel is lighted.

2 Set control unit DSCRM switch OFF, PWR switch ON, and wait 1 minute for warm-up. Monitor indicator CRT and audio, and press and hold SELF-TEST.	a. Fwd and aft strobes appear, extending to approximately the third circle on the indicator graticule, a 2.5 kHz (approximately) PRF audio present immediately. b. Within approximately 6 seconds, alarm audio present and the MA lamp starts flashing.
3 Rotate indicator BRIL control cw and ccw.	Indicator strobes brighten (cw) and dim as control is rotated. (Set control for desired brightness level.)
4 Rotate control unit AUDIO control between max ccw and max cw.	Audios not audible at max ccw and clearly audible at max cw.
5 Release SELF-TEST	All indications cease.
6 Set DSCRM to ON. Press and hold SELF-TEST.	a. Within approximately 4 seconds a fwd or aft strobe (either may appear first) and 1.2 kHz (approximately) PRF audio present.

Note

Occasionally during the period between pressing SELF-TEST and appearance of the first strobe, a distorted dot on the indicator and intermittent audio will be present. This is not a fault indication.

	b. Within approximately 6 seconds, the other strobe will appear, and PRF audio frequency will double. c. Several seconds later, alarm audio present, and MA lamp starts flashing.
7 Release SELF-TEST.	All indications cease.
8 Set control unit PWR switch OFF.	

Figure 15-5. Self-Test Procedure

		SEARCH	ACQUISITION	TRACK	MISSILE ACTIVITY
SA-2 FAN SONG RADAR	Audio	Similar to rattlesnake or Geiger counter	None	Similar to rattlesnake or Geiger counter	Activated – (low frequency pulsating tone)
	Visual	Rapidly flickering strobe	None	Rapidly flickering strobe	Activated – (rapidly flickering strobe)

Figure 15–6. FAN SONG Radar

		SEARCH	ACQUISITION	TRACK	MISSILE ACTIVITY
SA-3 LOW BLOW RADAR	Audio	Similar to chirping cricket	Same as Search	Medium to high pitched tone	Activated – (medium frequency pulsating tone)
	Visual	Rapidly pulsating strobe	Same as Search	Solid strobe	Activated – (pulsating strobe)
SA-4 PAT-HAND RADAR	Audio	Low frequency tone	Chirping sound	Steady low frequency tone	Activated – (steady low frequency tone)
	Visual	Intermittent strobe	Same as Search	Steady strobe	Activated – (steady strobe)
SA-6 STRAIGHT FLUSH RADAR	Audio	Low pitched audio with beep every 3 to 4 seconds	Same as Search but increase in tempo for audio and visual	Continuous low pitched tone	None
	Visual	Strobe flash every 3 to 4 seconds		Straight, steady strobe	None

Figure 15–7. LOW BLOW, PAT HAND, and STRAIGHT FLUSH Radars

		SEARCH	ACQUISITION	TRACK	MISSILE ACTIVITY
SA-8 LANDROLL RADAR	Audio	Similar to electronic TV ping-pong game	Same as Search	Medium to high pitched tone	None
	Visual	Intermittent STROBE	Same as Search	Steady strobe display	None
ZSU-23-4 GUNDISH RADAR	Audio	Steady, high pitched tone	Frequently modulating (similar to hammer striking chisel)	Steady high pitched tone	None
	Visual	Intermittent, wide bright strobe	Rapidly blinking strobe	Wide, bright steady strobe	None

Figure 15-8. LAND ROLL and GUN DISH Radars

		SEARCH	ACQUISITION	TRACK	MISSILE ACTIVITY
S-60 FLAPWHEEL RADAR	Audio	Intermittent audio beep (5 to 6 sec)	Same as Search but increase in tempo	Steady low pitched tone	None
	Visual	Intermittent strobe (5 to 6 sec)	Grows in length	Steady strobe	None

Figure 15-9. FLAP WHEEL Radar

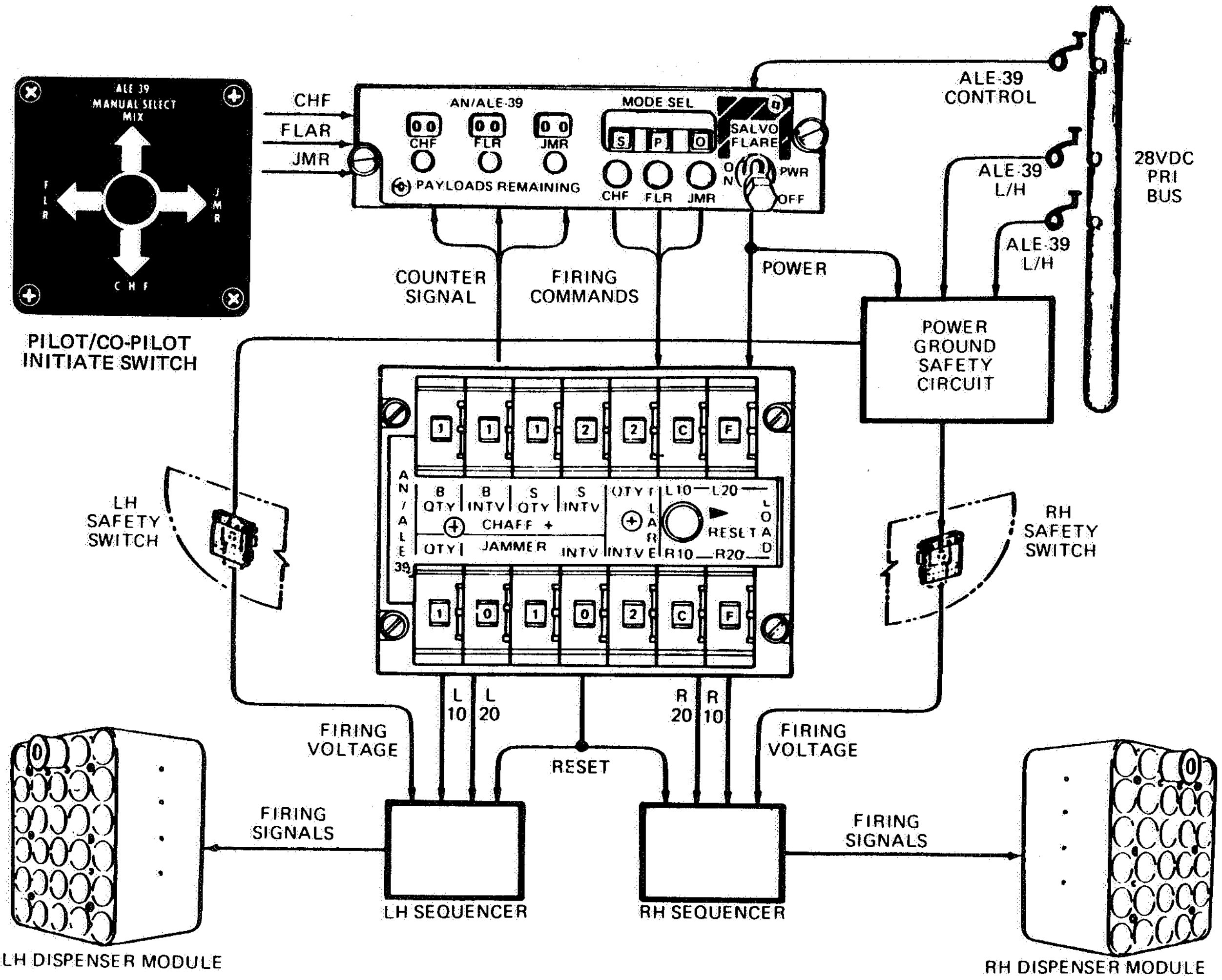


Figure 15-10. AN/ALE-39 System Components and Signal Flow

four sections. The countermeasures materials are ejected from the dispenser tubes by electrical signals controlled by the pilot. The programmer search and fire circuitry automatically senses the location of the selected type of payload in the dispensing sections. If the desired type of payload is not loaded or has been expended from one section, the system cascades to the next loaded dispenser section from which the dispensing sequence is completed.

Manual (single) dispensing or multiple programmed dispensing sequences of countermeasures materials can be selected on the pilot's cockpit control unit and dispensing initiated by either pilot by depressing the INITIATE switch. Manual dispensing can be performed during a programmed dispensing sequence without disrupting the program. Flare salvo dispensing can also be initiated by placing the POWER/FLARE SALVO switch on the pilot's cockpit control panel to the FLARE SALVO position. All remaining flares, regardless of loaded location, are dispensed in a rapid-fire sequence.

CAUTION

Flares located in subsections that are not identified in the programmer control panel as containing flares (f) will not dispense when the power/flare salvo switch is initiated.

Programmed dispensing routines for chaff, flares, and jammers are set into the programmer, and LOAD switches set to indicate which type of load is in each of the dispenser sections. Programmer controls for the programmed dispensing of countermeasures materials can be set to control the number of bursts (single firings) and the time lapse between bursts. In addition to burst quantity and interval control, the chaff programmed payload dispensing control includes the number of chaff salvos and the time lapse between chaff salvos in a programmed sequence.

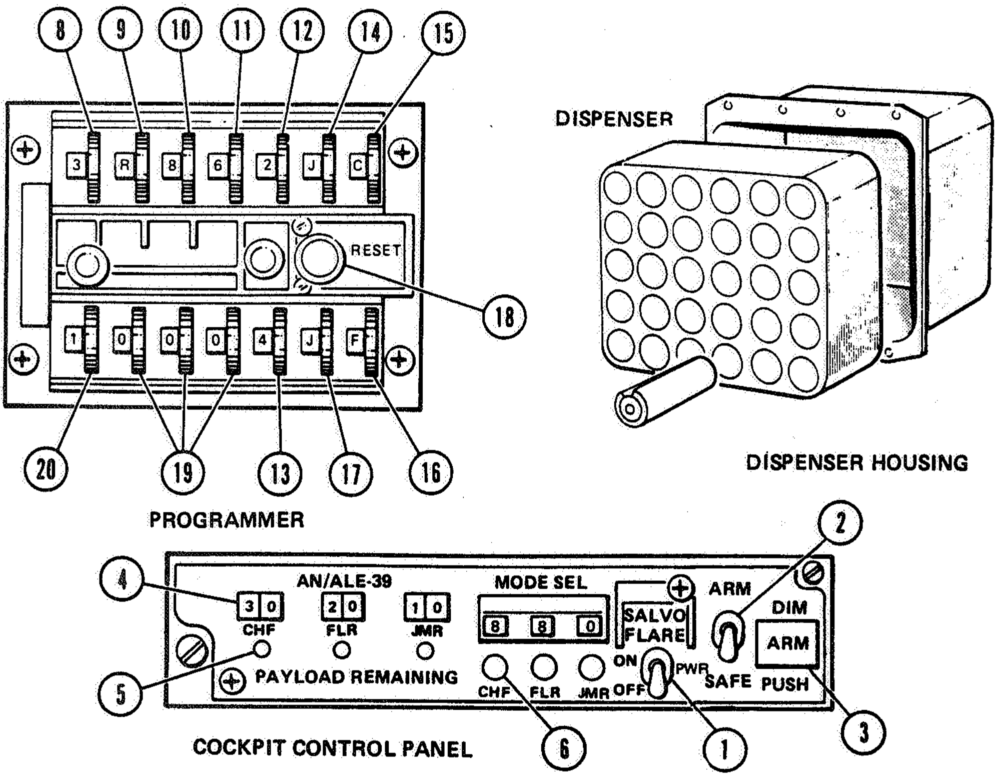
15.4.2 Controls and Indicators. The ALE-39 system controls (Figure 15-11) consist of a Dispensing Set Programmer, a Cockpit Control Unit, an Arm Switch, and Initiate Switches (one for each pilot) (Figure 15-11). The system is in the ready status when the dispenser safety pin has been removed, the arm switch has been activated, the armed light is ON, and the control panel selector switch is ON. A fire command can be initiated by the pilot or copilot for either manual or automatic dispense sequences.

15.4.3 Programming Selections

15.4.3.1 POWER/FLARE SALVO Switch. A POWER/FLARE SALVO lever lock toggle switch (Figure 15-11) has ON, OFF, and FLARE SALVO positions and is used to control primary 28 vdc power to the AN/ALE-39 programmer and to initiate the programmer flare salvo sequence.

15.4.3.2 Mode Selector Control Switches. Three rotary selector switches (Figure 15-11) are provided for selection of chaff (CHF), flare (FLR), and jammer (JMR) dispensing modes. The chaff and jammer mode selector switches have four positions: O (off), S (single), P (program), and R (RWR). The flare mode selector switch has eight positions: O (off), S (single), M (multiple), O (off), P (program), G (group), O (off), and R (RWR). These positions function as follows:

POSITION	FUNCTION
O (off)	Initiation of dispensing is not possible.
S (single)	Causes a single dispense command to the programmer for each actuation of the dispense INITIATE switch.
P (program)	Causes a programmed dispense command to be sent to the programmer for each activation of the dispense INITIATE switch.
R (RWR)	Causes a single dispense command to be sent to the programmer for each activation of the dispense INITIATE switch.



NOMENCLATURE	FUNCTION
1. Power switch	OFF – Power off to ALE-39 ON – Activates ALE-39 Salvo Flare – Fires all flares in dispensers
2. ALE-39 Arm switch	OFF – Disables ALE-39 ON – Master arm switch for ALE-39
3. Arm light	Extinguished when Switch #2 is OFF or when Switch #2 is on dispensers installed. Armed light is on when switch ON and ARM pin removed.
4. Counters	Indicates number of payloads, by type, remaining in dispensers. C – chaff F – flare J – rf jammer
5. Payload reset	Sets quantity of each type of payload loaded.

Figure 15-11. Countermeasures Dispensing System (Sheet 1 of 3)

NOMENCLATURE	FUNCTION
6. Mode Select switches (one for each countermeasure)	O – Disables that countermeasure S – Single, one countermeasure per actuation of pilot jettison switch P – Program initiates program sequence as per programmer R – RWR, series of payloads will be dispensed under control of the radar warning receiver M – Multiple, burst of 2, 3, or 4 flares in parallel, depending on the number of dispenser sections containing flares G – Group, multiple bursts of flares dispensed as per programmer
7. Dispenser switches pilot/copilot	Push to dispense Push to initiate dispense sequence
	CHAFF Section
8. B QTY switch	1, 2, 3, 4, C, or R selects number of chaff bursts in one salvo (C is continuous and R is random).
9. B INTV switch	1, 2, 5, 7, 10 or R selects time interval between chaff bursts of each salvo in seconds (R is random).
10. S QTY switch	1, 2, 4, 8, 10, or 15 selects number of chaff salvos required to end programmed sequence.
11. S INTV switch	2, 4, 6, 8, or 10 selects time interval between chaff salvos in seconds
	FLARE Section
12. QTY switch	2, 3, 4, 6, 8, or 10 selects number of flare bursts required to end flare programmed sequence.
13. INTV switch	2, 4, 6, 8, or 10 selects time interval, in seconds, between bursts in programmed sequence.
	LOAD Section
14. L10 switch	C, F, or J indicates type of payload in L10 dispenser.
15. L20 switch	C, F, or J indicates type of payload in L20 dispenser.
16. R20 switch	C, F, or J indicates type of payload in R20 dispenser.
17. R10 switch	C, F, or J indicates type of payload in R10 dispenser.
18. RESET switch	When pressed (3 seconds minimum) clears all registers and counters in programmer and resets sequencer switches.
	JAMMER Section
19. INTV switches	Selects in seconds the time interval between bursts of programmed sequence (continuous from 000 thru 299).
20. QTY switch	1, 2, 3, or 4 selects number of jammer bursts required to end programmed sequence.

*Refer to NAVAIR 16-30A39-1, Intermediate Maintenance Manual, for a discussion of programmer operation.

Figure 15-11. Countermeasures Dispensing System (Sheet 2 of 3)

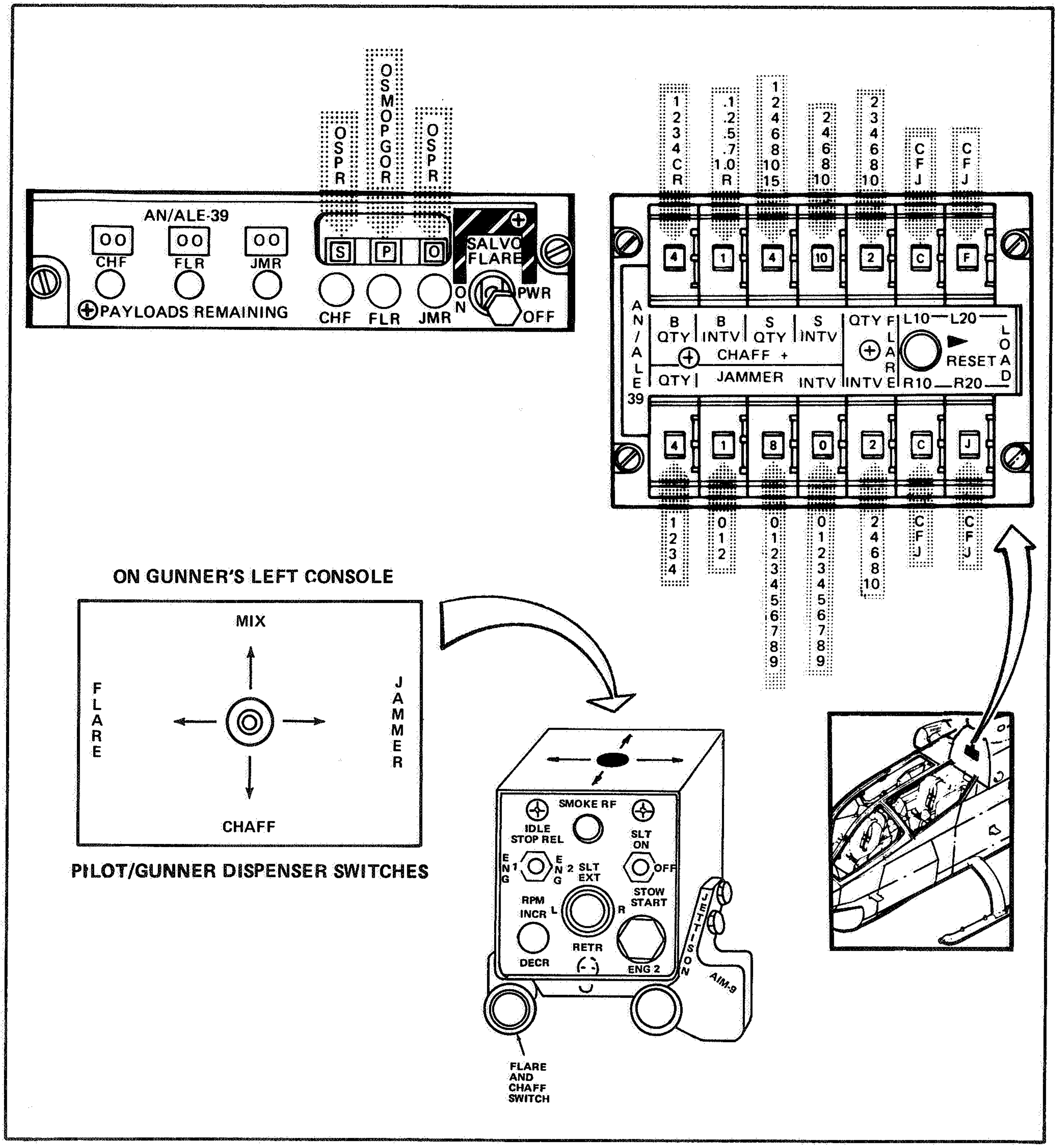


Figure 15-11. Countermeasures Dispensing System (Sheet 3 of 3)

POSITION	FUNCTIONS
M (multiple)	A command to the programmer to cause it to dispense flare payloads (one per available subsection) in parallel, if available, and is initiated by activation of the flare dispense INITIATE switch.
G (group)	A combination command of P and M modes which causes the programmer to expend flare payloads from all available sections in parallel in the quantity and time interval selected by the programmer.

15.4.3.3 LOAD REMAIN Display Counter. Three LOAD REMAIN subtractive counters are provided to indicate the number of unfired CHF (chaff), FLR (flare), and JMR (jammer) cartridges remaining in the dispensers. Each counter has a reset knob to allow manual setting or resetting of each display to all integers between 00 and 99. The counters have mechanical stops at 00 and are not damaged by additional decrementing counter signals.

15.4.3.4 Programmer Control Panel. The programmer unit (Figure 15-12) accepts command signals from the cockpit control unit and provides the two sequencer switches with stepping pulses for dispensing countermeasures payloads from the dispensers.

Note

> Because of the location of the programmer (behind the pilot's seat), airborne reprogramming is all but impossible. Ensure the programmer selection is briefed, understood, and set prior to launch.

15.4.3.4.1 CHAFF B QTY Switch. The CHAFF B QTY switch has positions 1, 2, 3, 4, C, and R which select the number of chaff bursts in one salvo. The C position permits continuous dispensing of individual bursts at the rate selected on the CHAFF B INTV switch. Dispensing continues until all chaff has been expended or until the dispenser control POWER/FLARE SALVO switch is positioned to OFF. The R position permits a random number of bursts in one salvo (four minimum or six maximum).

15.4.3.4.2 CHAFF B INTV Switch. The CHAFF B INTV switch has positions .1 (.125 second), .2 (.25 second), .5 (.5 second), .7 (.75 second), 1.0 (1 second), and R (Random) which select the time interval in seconds between each chaff burst in a salvo. With the CHAFF B INTV switch in R, the first three bursts of the salvo are .125 second apart. Additional bursts of 1, 2, or 3 are fired at random time intervals of either .25, .5, .75, 1, 1.5, 2, 3, or 4 seconds when CHAFF B QTY switch is at R or C. If CHAFF B INTV switch is on R and CHAFF B QTY is not on R or C, a single chaff payload is dispensed.

15.4.3.4.3 CHAFF S QTY Switch. The CHAFF S QTY switch has positions of 2, 4, 6, 8, 10, and 15 which select the number of chaff salvos in one programmed sequence.

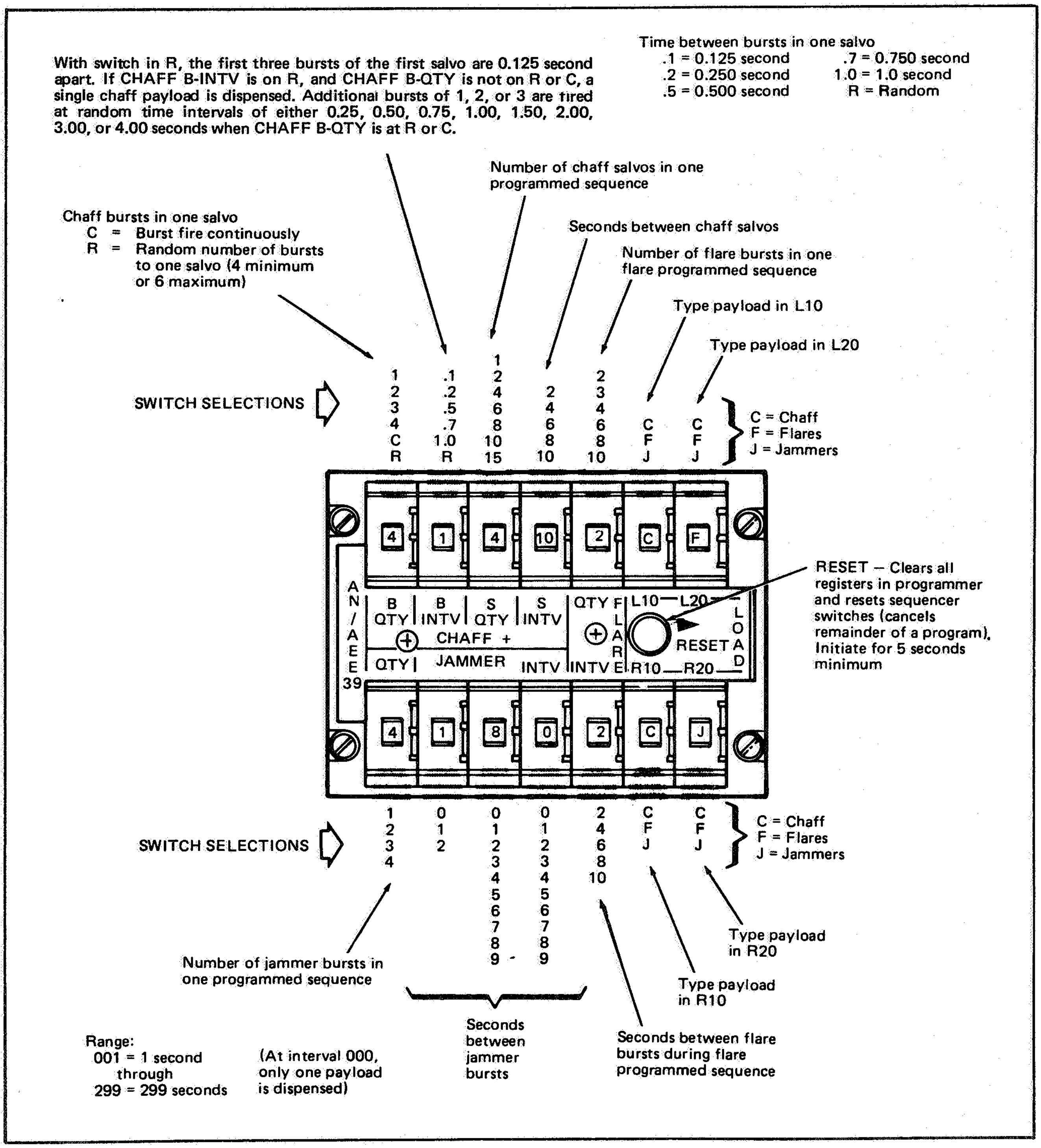
15.4.3.4.4 CHAFF S INTV Switch. The CHAFF S INTV switch has positions of 2, 4, 6, 8, and 10 which select the time interval in seconds between ejection of each salvo in an automatic sequence.

15.4.3.4.5 JAMMER QTY Switch. The JAMMER QTY switch has positions of 1, 2, 3, and 4, which select the number of jammer bursts in one programmed sequence.

15.4.3.4.6 JAMMER INTV Switches. The three JAMMER INTV switches provide for selection of time interval between jammer bursts from 1 to 299 seconds.

15.4.3.4.7 FLARE QTY Switch. The FLARE QTY switch has positions 2, 3, 4, 6, 8, and 10 which select the number of flare bursts in one flare programmed sequence.

15.4.3.4.8 FLARE INTV Switch has positions of 2, 4, 6, 8, and 10 which select the time interval in seconds between flare bursts during flare programmed sequence.



With switch in R, the first three bursts of the first salvo are 0.125 second apart. If CHAFF B-INTV is on R, and CHAFF B-QTY is not on R or C, a single chaff payload is dispensed. Additional bursts of 1, 2, or 3 are fired at random time intervals of either 0.25, 0.50, 0.75, 1.00, 1.50, 2.00, 3.00, or 4.00 seconds when CHAFF B-QTY is at R or C.

Time between bursts in one salvo

.1 = 0.125 second	.7 = 0.750 second
.2 = 0.250 second	1.0 = 1.0 second
.5 = 0.500 second	R = Random

Number of chaff salvos in one programmed sequence

Chaff bursts in one salvo
C = Burst fire continuously
R = Random number of bursts to one salvo (4 minimum or 6 maximum)

Seconds between chaff salvos

Number of flare bursts in one flare programmed sequence

Type payload in L10

Type payload in L20

RESET – Clears all registers in programmer and resets sequencer switches (cancels remainder of a program). Initiate for 5 seconds minimum

Number of jammer bursts in one programmed sequence

Seconds between jammer bursts

Seconds between flare bursts during flare programmed sequence

Type payload in R10

Type payload in R20

Range:
001 = 1 second
through
299 = 299 seconds

(At interval 000, only one payload is dispensed)

Figure 15-12. AN/ALE-39 Programmer

15.4.3.4.9 L10, L20, R10, R20 LOAD Switches. The four LOAD switches have positions of C (chaff), F (flares), and J (jammers) which are set by ground personnel to indicate which type of load is in each of the four dispenser sections.

15.4.3.4.10 RESET Switch. The RESET switch is used to clear all registers in the programmer and resets the sequencer switches (cancels remainder of a program). Must be activated for at least 5 seconds; must be activated every time you reset something.

15.4.3.4.11 INITIATE Switch Panel. An INITIATE switch (Figure 15-11) is located on the pilot's collective and on the gunner's left console. The multiposition, momentary toggle switch has positions of CHF, FLR, JMR, and MIX with center position off. Momentarily depressing the switch to CHF, FLR, or JMR will initiate a dispense function to the programmer as selected on the pilot's countermeasures dispenser control panel. Depressing the MIX will initiate dispensing of two bursts of flares (one from each side) and one burst of chaff (from the left side) if "R" is selected on any mode switch of the programmer and the cockpit control unit is set with "S" in CHF, "M" in FLR, and "R" in JMR (Figure 15-11).

15.4.4 Countermeasures Dispensing Set Operation. The countermeasures dispensing set is placed in operation by the POWER/FLARE SALVO switch to the ON position. This applies +28 vdc to the programmer and enables the search and fire circuitry. The arming handle near the dispensers must be armed and the safe/arm switch on the arm control panel must be placed in the arm position. With all three switches thus positioned, the arm light on the arm control panel will illuminate and the system is ready for operation. Countermeasures materials may be dispensed manually or automatically (programmed). Manual (single) dispensing of chaff, flares, or jammers can be performed during a programmed dispensing sequence without disrupting the program. The programmer is located at the foot of the pedestal. The number of bursts and the time lapse between bursts for programmed dispensing of chaff, flares, and jammers, and the number of chaff salvos and the time lapse between chaff salvos in a programmed sequence are selected on the programmer control panel. On the countermeasures cockpit control unit, set the LOAD REMAIN display counters to indicate the number of each type payload material (chaff, flares, jammer) loaded in the dispensers. Flares may be salvoed at any time (in flight) by placing the POWER/FLARE SALVO switch to the FLARE SALVO position. All remaining flares, regardless of loaded location, are dispensed in a rapid-fire sequence.

15.4.4.1 Manual Operation (Single Dispensing). After the dispensing system is placed in operation by positioning the POWER/FLARE SALVO switch to ON, position the mode selector switches on the cockpit control unit to the indicated position.

1. CHF mode switch — "S" (single)
2. FLR mode switch — "S" (single) or "M" (multiple)
3. JMR mode switch — "S" (single).

With the mode switches in "S" position, momentarily depressing the INITIATE switch to either CHF, FLR, JMR, or MIX will dispense one payload of selected countermeasures material. With the FLR mode switch in "M" position, depressing the INITIATE switch to FLR will dispense from one to four flares simultaneously as a single dispense, depending on how the four sections of the dispensers are loaded. If three sections have flares loaded, three flares can be fired simultaneously, or if only one section has flares loaded, a single flare will be fired.

15.4.4.2 Automatic Operation (Programmed Dispensing). After the dispensing system is placed in operation by positioning POWER/FLARE SALVO switch to ON, position the mode selector switches on the cockpit control unit to the desired position.

15.4.4.2.1 Chaff Dispensing. Place CHF mode switch to "P" position. With the mode switch in "P" position, momentarily depressing the INITIATE switch to CHF will initiate a programmed sequence of dispensing chaff payloads from the dispensers. The number of salvos, number of bursts for each salvo, timing interval between bursts, and time interval between salvos are determined by the setting of the programmer switches (CHAFF B QTY, CHAFF B INTV, CHAFF S QTY, and CHAFF INTV). With the CHAFF B QTY switch in "C" (continuous), the individual bursts are dispensed continuously at the rate determined by the position of the CHAFF B INTV switch.

Note

> Continuous dispensing can only be terminated by positioning the POWER/FLARE SALVO switch to OFF.

The positions of the CHAFF QTY and CHAFF INTV switches are meaningless when the CHAFF B QTY switch is in "C."

15.4.4.2.2 Jammer Dispensing. Place JMR mode switch to "P" position. With the mode switch in "P" position, momentarily depressing the INITIATE switch to JMR will initiate a programmed sequence of dispensing jammer payloads from the dispensers. The number of jammer bursts in one programmed sequence and the time interval between jammer bursts are determined by the setting of the programmer switches (JAMMER QTY and JAMMER INTV).

15.4.4.2.3 Flare Dispensing

1. Place FLR mode switch to "P" position. With the FLR mode switch in "P" position, momentarily depressing INITIATE switch to FLR will initiate a programmed sequence of dispensing flare payloads from the dispensers. The number of flare bursts in one programmed sequence and the time intervals between flare bursts are determined by the settings of the programmer switches (FLARE QTY and FLARE INTV).

2. Place FLR mode switch to "G" position. With the FLR mode switch in "G" position, momentarily depressing the INITIATE switch to FLR will initiate a programmed sequence of dispensing multiple flare payloads (up to four flare dispensed simultaneously) from the dispensers. The number of multiple flare bursts in one programmed sequence and the time intervals between flare bursts are determined by the settings of the programmer switches (FLR QTY and FLR INTV).

15.4.4.2.4 Countermeasures Dispensing

1. Manual Operation (Single dispensing)

   (a) POWER/FLARE SALVO switch . . . . ON

   (b) CHF mode switch . . . . S

   (c) FLR mode switch. . . . . S or M

   (d) JMR mode switch . . . . S

   (e) INITIATE switch (Pilot's or Observer's). . . . . CHF, FLR, or JMR (As Required)

Note

> With FLR mode switch in M position, a multiple dispense of one to four flares will be released simultaneously if flares are loaded in more than one dispenser section.

2. Automatic Operation (Programmed)

   (a) POWER/FLARE SALVO switch . . . . ON

   (b) CHF mode switch . . . . P

   (c) FLR mode switch. . . . . P or G

   (d) JMR mode switch . . . . P

   (e) INITIATE switch (Pilot's or Observer's). . . . . CHF, FLR, or JMR (As Required)

Note

With FLR mode switch in (G) position, a programmed sequence of multiple flare payloads will be dispensed.

3. Flare Salvo

(a) POWER/FLARE SALVO switch . . . . FLARE SALVO

15.5 AN/ALQ-144 JAMMER

The AN/ALQ-144 (Figure 15-13) is an infrared jammer. It is mounted above the engines and is an omnidirectional system which confuses the guidance mechanisms of selected infrared missiles. The set consists of two units, the cockpit control unit and the transmitter.

The Cockpit Control Unit is located on the pilot's control panel and contains an INOP lamp mounted near the sight on the pilot's glare shield and the ON-OFF switch.

The source plus the rest of the set uses a maximum of 1.5 KW from the aircraft 28 vdc source, which produces a current drain of about 54 amperes. This fact should be taken into consideration during any electrical emergency.

The transmitter consists of a heat source, high- and low-speed modulators, covert window, and housing assembly. The transmitter generates and modulates heat and passes it through the covert window as invisible IR energy. It is located just above the exhaust pipe. The heat source and other components are cooled by forced air, and the hot air then exhausts from openings in the top of the transmitter.

15.5.1 Operating Procedures

1. IR JAMMER circuit breakers — In (XMTR, CONT, and BASE)

2. ON/OFF switch — ON

Operate the AN/ALQ-144 for a minimum of 15 minutes if no fault conditons exist. After flight or when ALQ-144 is no longer needed, turn ON/OFF switch OFF. The IRCM light will illuminate for approximately 60 seconds after power is removed from the system.

If a fault condition exists in the AN/ALQ-144, the IRCM light will illuminate approximately 60 seconds after power is applied and will automatically turn off the AN/ALQ-144. The IRCM light will remain illuminated for approximately 60 seconds when the fault condition is encountered.

If IRCM light illuminates:

1. ON/OFF switch — OFF

2. Wait until IRCM light extinguishes (approximately 60 seconds)

3. ON/OFF switch — ON.

If IRCM light does not illuminate, system will operate normally.

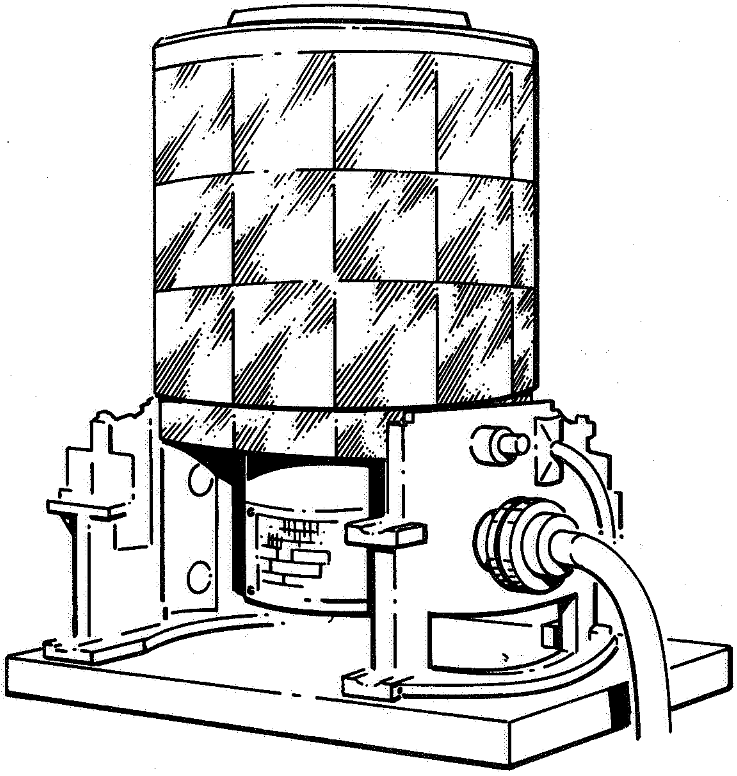
If IRCM light illuminates (internal failure of AN/ALQ-144); ON/OFF switch — OFF.

The IRCM INOP light indicates a system malfunction. The following conditions will light these lamps: modulator speeds are out of tolerance, the source output drops below a fixed reference, or overheating occurs because of a fault in blowing cool air over the transmitter components. All of these faults will also cause the transmitter to shut down.

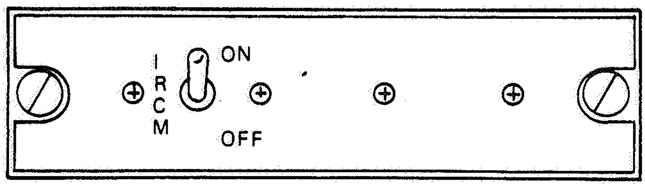
15.6 ADVANCED EW EQUIPMENT

15.6.1 AN/APR-44 Radar Warning Receiver. The AN/APR-44 (Figure 15-14) is a radar warning receiver designed to warn the pilots that the aircraft is being tracked by continuous wave (CW) radar. Certain radar systems utilize CW radar for tracking and missile guidance purposes. The APR-39(V)1 will not receive and process these signals. The APR-44 will process these signals and provide the pilots with a visual and aural warning. The APR-44 does not interface with the APR-39 in this regard.

15.6.2 AN/APR-39A. The AN/APR-39A is an update of the APR-39(V)1. It will receive,



IR TRANSMITTER UNIT



CONTROL UNIT

Figure 15-13. ALQ-144 IR Jammer Components

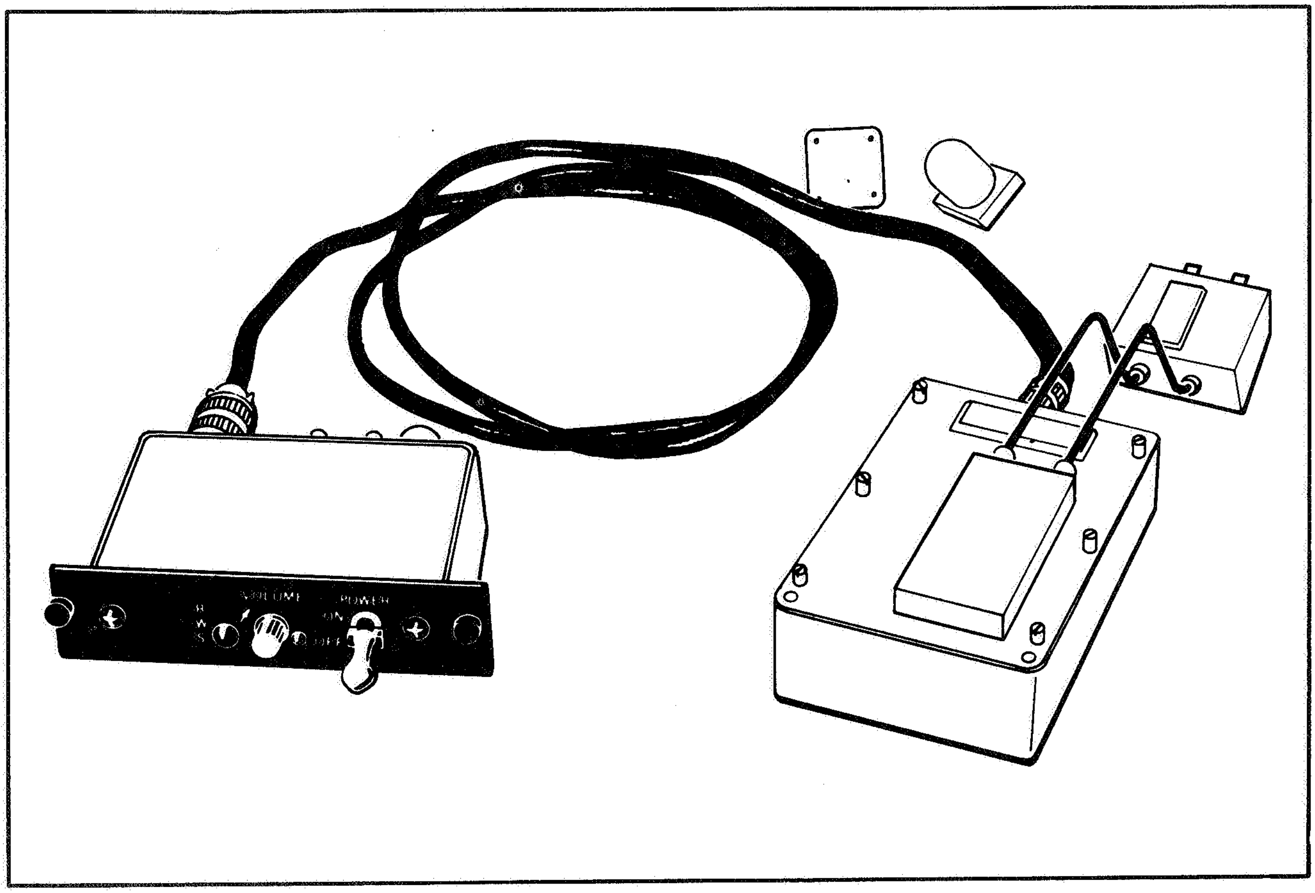


Figure 15-14. AN/APR-44 Radar Warning Receiver

process, and display radar signals in the 6 to 100 GHz range. The display is by alpha-numeric symbology with associate voice warning. Various interfaces may be routed through the APR-39A to provide warning of CW radar and laser emergency signals.

15.6.3 AN/AVR-2. The AN/AVR-2 is a laser warning receiver designed to detect laser energy which is illuminating the aircraft and provide a warning to the pilots.

CHAPTER 16

Chemical, Biological, and Radiological Missions

16.1 GENERAL

Nuclear, biological, and chemical (NBC) warfare poses substantial hindrances to the successful accomplishment of the aviation mission in the high-threat environment. The availability to Threat Forces of sophisticated, highly mobile delivery systems for NBC munitions has been well documented.

NBC weapons are viewed by Threat Forces as weapons of mass destruction. Heavy emphasis is placed on training with these weapons, as evidenced by operations and war games being conducted in a near-real environment.

If Threat Forces fail to achieve their objectives with conventional munitions and make the decision to use NBC weapons, the aviator can expect the NBC environment to contain a mix of conventional, chemical, nuclear, and possibly biological weapons. It would not be unlikely for an aviator to encounter two or possibly all three threats during the same mission. This is particularly true of chemical and nuclear attacks which have similar target priorities. In the high-threat NBC environment, aviators must fly fully clothed in chemical protective garments because once airborne and an NBC attack occurs, it will be virtually impossible for aircrews to get into protective clothing before becoming casualties.

The primary countermeasure to this threat must be the ability to continue operations while subjected to a nuclear, biological, or chemical attack. Training must be realistic, rigorous, and repetitive to achieve a state of readiness in this area. NBC warfare must not impair the ability to survive, fight, and win.

16.2 NUCLEAR THREAT

The nuclear delivery means available to the Threat Forces can reach from the forward edge of the battle area to the rearmost boundaries of the theater. These systems include short-range ballistic missiles, rockets, aircraft, and artillery. A primary target for enemy nuclear employment will be our aviation assets.

16.2.1 Nuclear Weapons Effects. A nuclear detonation results in a fireball formed as the result of the sudden release of immense energy. Temperatures ranging into the millions of degrees coupled with initial pressure ranges to millions of atmospheres are formed inside the fireball, creating devastating physical changes in the normal balance of the environment. This release of energy causes a shock or blast wave. In addition, nuclear weapons emit nuclear and thermal (or heat) radiation and electromagnetic energy. See Figures 16-1 thru 16-3.

16.2.1.1 Blast and Shock. Blast and shock account for most of the materiel damage and a considerable number of the casualties after a nuclear detonation. As the intensely hot gases expand within the fireball, the resultant high pressures cause a blast wave to form in the air, moving outward at high velocities. The blast wave is characterized by the abrupt rise in pressure above ambient conditions. The damage mechanisms for air blast result from two areas: overpressure and dynamic pressure.

16.2.1.2 Overpressure. As the blast wave reaches an object, such as an aircraft, high initial pressures are applied to the side of the aircraft nearest the burst, while the side of the

ORIENTATION	Eyes focused on point of detonation.	Burst in field of vision but not focused on point of burst.	Personnel shielded or looking away.
FLASH BLINDNESS	Yes: Recovery in approximately 2 minutes.	Yes: Recovery in less than 2 minutes.	Not very likely.
LOSS OF NIGHT ADAPTATION	NA	NA	NA
RETINAL BURNS	Very likely.	Possible.	No.

Figure 16–1. Daytime Visual Effects of Nuclear Detonation

ORIENTATION	Eyes focused on point of detonation.	Burst in field of vision but not focused on point of burst.	Personnel shielded or looking away.
FLASH BLINDNESS	Yes: Recovery gradual in 10 minutes or less. Will depend on visual task to be performed and level of illumination.	Yes: Recovery in approximately 5 minutes or less for most situations. Depends on visual task to be performed and level of illumination.	Possible from reflection. Recovery in 2 to 3 minutes for most situations. Depends on visual task to be performed and level of illumination.
LOSS OF NIGHT ADAPTATION	Yes: Recovery gradual in 15 to 35 minutes.	Yes: Recovery in 15 to 35 minutes.	Possible: Recovery in no less than 15 minutes.
RETINAL BURNS	Very likely.	Possible.	No.

Figure 16–2. Nighttime Visual Effects of Nuclear Detonation

*THERMAL RADIATION – Either heat, light, or combination of both which can damage the aircraft and burn the aviator.

*NUCLEAR RADIATION – Total dose absorbed by aviator may be incapacitating or lethal.

*BLAST – Overpressure and dynamic pressure absorbed by aircraft may cause structural damage or failure.

ELECTROMAGNETIC PULSE – May destroy/degrade aircraft electronic systems.

Figure 16–3. Categories of Danger to Aircraft and Aviators

aircraft away from the burst is still at ambient pressure differential about the aircraft. As the blast wave envelops the aircraft, the overpressure is applied to all sides of the aircraft and produces a squeezing or crushing force on the aircraft which may result in damage.

16.2.1.3 Dynamic Pressure. Dynamic pressure is a measure of the force exerted by winds associated with the blast wave. Dynamic pressure can cause damage by pushing, tumbling, or tearing the target apart.

Parked aircraft and aircraft in flight are damaged by a combination of overpressure and dynamic pressure. Aircraft plexiglass windows are particularly vulnerable to low overpressure effects.

16.2.1.4 Thermal Radiation. Thermal radiation results from the heat and light produced by the nuclear explosion within the atmosphere. While flying, aviators are particularly vulnerable to the effects of thermal radiation because of their inability to protect themselves.

Thermal burns are produced either directly as flash burns or indirectly by fires caused by the detonation. Exposed skin areas may be burned by intense heat, or burns may result from combustible material in the aircraft catching fire. The fire-resistant characteristics of the nomex flight suit, gloves, and leather boots will help protect aviators from thermal radiation.

Because of the intense brightness of the flash of light produced by the nuclear explosion, a temporary (flash blindness) or permanent (retinal burns) loss of vision may result.

16.2.1.5 Flash Blindness. Flash blindness (dazzle) is a temporary impairment of vision caused by the saturation of the light-sensitive elements (rods and cones) in the retina of the eye. It is an entirely reversible phenomenon which normally will blank out the entire visual field of view with a bright after-image. Normally, flash blindness will be brief and recovery complete. Flash blindness may be produced by scattered light and does not necessarily require eye focusing of the fireball. Flash blindness will be more severe and recovery slower at night since the pupil is larger than during the day, and the object being viewed and the background usually are dimly illuminated. Flash blindness is considered a hazard to aviators because of the probability of an aircraft crash if the aviator is temporarily blinded.

16.2.1.6 Retinal Burns. A retinal burn is a permanent eye injury that occurs when the retinal tissue is heated excessively by the focused image of the fireball within the eye. The visual capacity is permanently lost in the burned area. The natural tendency of personnel to look directly at the fireball tends to increase the probability of retinal burns. Under certain conditions, retinal burns may be produced as far away as the horizon on a clear night. A retinal burn is painless and normally will not be noticed by the individual concerned if it is off the central axis of vision. However, very small burned areas may be noticeable if they are centrally located. Personnel generally will be able to compensate for a small retinal burn by learning to scan around the burned area.

16.2.1.7 Initial Nuclear Radiation. Initial nuclear radiation is defined as that nuclear radiation emitted by a nuclear explosion within the first minute after the burst. The primary casualty producers associated with initial nuclear radiation are neutrons and gamma rays. Personnel are extremely vulnerable to initial nuclear radiation; and, for yields of 50 kilotons (kT) or less, it is the dominant casualty producer.

16.2.1.8 Residual Nuclear Radiation. All nuclear radiation emitted from radioactive particles that a nuclear burst produces after that first minute is called *residual radiation.* Dirt and debris from the ground are sucked up into the fireball and carried by the wind. While flying, aviators will be exposed to residual radiation for only short periods. Therefore, the radioactive hazard is small. However, aviators should avoid flying through airborne debris or clouds which may have been contaminated, since high levels of radiation may be encountered even if the exposure time is very short.

16.2.1.9 Electromagnetic Pulse (EMP). EMP is an intense flux of electromagnetic energy that moves out from the nuclear burst at approximately the speed of light. As this flux moves out, it causes current flow in all conductive materials in its path. Excessive current is generated in antennas, long wire and cables, metal objects, radios, and electronic equipment. The excessive current can cause arc-over, burning, and destruction of equipment. Because of the electromagnetic nature of the flux, it travels farther than blast, affects objects shielded from thermal radiation, and it is difficult to predict the extent of the area which will be affected. Effects vary from complete burning out (from arc-over) to temporary or permanent circuit disturbances caused by reverse or excessive current flow. The effects of EMP can be generally categorized into two areas: near surface and exoatmospheric.

1. Near Surface. Effects are generally localized in the area of the blast and consist of damage done to electronic equipment. This damage can be classified as temporary (e.g., tripping of circuit breakers or alteration of memory banks) or permanent (e.g., burning out of components or reversal of components polarity).

2. Exoatmospheric (outside the Earth's atmosphere). Effects are much more far reaching than the near-surface bursts. The effects travel on the line of sight, thus covering very large areas and, perhaps, affecting entire continents. A simple way of assessing these effects is to experience communications blackouts. These effects are temporary and last no more than a few hours.

16.2.2 Countermeasures Against the Nuclear Threat. Since the hazards associated with nuclear weapons are so unique, aviation countermeasures are dependent on many elements. For example, with a 1-kiloton detonation, the difference between the distance where one is a certain casualty and the distance where one may assume one is reasonably safe is only 300 meters.

The key to surviving a nuclear threat consists of three factors: prior warning by a STRIKEWARN (warning of a friendly nuclear strike), distance from the blast, and flight altitude. The aviator must keep in mind that once a nuclear blast occurs, a decision on what action to take will have to be made immediately because it will only take a few seconds for the shock wave to reach the aircraft. If flying at terrain flight altitudes, the probability of survival will be best if the aviator puts the helicopter on the ground. He should turn the nose of the helicopter away from the blast to present a small area for the shock wave to strike. As the aircraft rests on the ground, he should put the visor down and place his head as low as conditions permit while maintaining control of the aircraft. After the shock wave passes, he should check the aircraft for structural damage and, if possible, continue his mission.

If flying above terrain flight altitudes, and sufficient time is not available to land, the pilot should initiate a climb and turn away from the blast to minimize the effects of the nuclear explosion.

16.2.3 Actions To Be Taken After Nuclear Attack. As soon as the blast wave has passed, radiological monitoring should commence to detect radiological contamination of equipment and personnel. Radios possibly will be affected by EMP. Unit commanders should be prepared to carry out their assigned missions in radio silence. Therefore, operational plans should include provisions for mission continuation even without radios.

16.3 BIOLOGICAL WEAPONS EFFECTS

Biological weapon systems are unique in that the agents involved are alive or the toxic products of living organisms. Only a small number of microorganisms are needed to inflict casualties. The agents reproduce in the host and cause disease. The area covered by biological weapon systems can be up to many thousands of square kilometers. Biological agents do not produce casualties immediately because time is required to overcome the body's internal defense mechanisms.

Biological agents are living microorganisms or their byproducts which cause diseases in man, animals, or plants, or cause the deterioration of material.

There are several kinds of microorganisms or germs that can be used as biological agents. These agents include bacteria, rickettsia, viruses, and fungi. They have different characteristics, cause different diseases, and require different methods of treatment (Figure 16-4).

Germs can enter the body in three ways: through the skin, through the respiratory tract, and through the digestive tract. Some germs can attack one way and cause a rather minor disease or attack another way and cause a high percentage of sickness or death. As illustrated in Figure 16-5, there are three forms of anthrax that affect man: cutaneous (skin), pulmonary (respiratory tract), and intestinal (by ingestion). The mortality rate of the pulmonary form may exceed that of the cutaneous form by 75 percent.

16.3.1 Countermeasures Against a Biological Threat. Biological agents can be delivered in various forms, chiefly by spray and bomblets. Infective vectors, such as ticks, fleas, or mosquitoes, also might be used (Figure 16-6).

16.3.2 Before the Attack. The measures taken before the attack are designed to minimize the effect of the agent on personnel.

16.3.2.1 Personal Hygiene and Area Sanitation. These measures are important in routine preventive medicine and are implemented in every unit. During normal situations, these measures tend to reduce the incidence of infectious disease and promote the general health of the individual and unit. The infective dosage is in part dependent on the physical condition of the exposed individual. Area sanitation plays an important part in defense against a biological attack by preventing rodents and other vectors from transmitting disease to previously unexposed personnel.

16.3.2.2 Immunization. The use of immunization procedures provides protection against several biological agents and airborne vectors such as mosquitoes. Disease sympthoms are less severe or absent in immunized individuals. An enemy might hesitate to use a particular agent against troops protected by immunization because he could not be sure of the results. It also would be unlikely for Threat Forces to employ the use of airborne vectors since their movement after release is unpredictable. The assumption must not be made that immunization is the only defense needed against biological agents. Effective immunization procedures are not available for all potential biological agents, and acquired immunities to some agents may be overcome if the dosage is sufficiently high.

16.3.3 During the Attack. The measures taken by troops while under biological attack are similar to those taken while under chemical attack. The most important single item of protective equipment is the mask, as it provides protection from spraying and aerosol delivery of biological agents. The importance of proper fit, adjustment, and maintenance of the protective mask and hood cannot be overemphasized. Protective clothing is not necessary for protection against field concentrations of biological agents. Normal clothing, buttoned and arranged so that all skin areas are covered, will give good protection. Any open wounds should be bandaged.

BIOLOGICAL AGENTS–

- Are characterized by a low agent requirement – very little goes a long way.
- Cover a large area.
- Are weather dependent.
- Have a delayed effect.
- Easily penetrate fortifications, buildings, etc.
- Do not destroy material.
- Are hard to detect.
- Decay with time.
- Are easy to manufacture.
- May have graduated severity.

Figure 16-4. Characteristics of Biological Agents

16.3.4 After the Attack. Because units have no devices to indicate when a biological hazard no longer exists, individuals continue wearing the protective masks after a suspected biological attack until authorized by their commanders to remove them. After a suspected biological attack, other actions which may be necessary are as follows.

16.3.4.1 Decontamination. Generally, decontamination of personnel and equipment is not a matter of immediate urgency in the field when biological agents are disseminated as an aerosol. Decontamination usually is carried out when time and resources permit. Some methods for use in the field for the decontamination of biological agents are discussed below. For detailed information on large-scale decontamination operations refer to FM 3-5.

16.3.4.1.1 Personnel. Individuals can decontaminate themselves by showering with hot water and soap; germicidal soaps are used, if available. The nails should be thoroughly cleaned and hairy parts of the body scrubbed. Contaminated clothing should be washed in hot, soapy water if it cannot be sent to a field laundry for decontamination. Cotton items may be boiled.

16.3.4.1.2 Outdoor Areas. Sunlight kills most microorganisms and usually will decontaminate unshaded outdoor areas. However, shaded areas, especially at low temperatures, may remain hazardous from several hours to several

POSSIBLE AGENT	SYMPTOMS	SOURCE OF INFECTION	METHOD OF ENTRY	MORTALITY		TIME BETWEEN EXPOSURE AND SYMPTOMS
				TREATED	UNTREATED	
ANTHRAX Cutaneous	Swelling, ulcerated sores	Infected livestock, through skin scratches, imported animal hides	Skin	Up to 5%	Up to 25%	1-7 days
ANTHRAX Intestinal	Abdominal pain, nausea, vomiting, fever, shock, death	Insufficiently cooked meat from infected animals, contaminated water	Mouth	Up to 100%	Up to 100%	1-7 days
ANTHRAX Pulmonary	Fever, cough, respiratory distress	Spores breathed into lungs	Lungs	Up to 100%	Up to 100%	1-5 days
BRUCELLOSIS (Undulant Fever)	Fever, joint pain, malaise; illness may last months	Milk; infected goats, cattle, hogs, dogs	Mouth, skin, lungs,	Approaches 0	2 to 6%	Usually 6-21 days (may be several months)
TULAREMIA (Rabbit Fever)	Chills, fever, disease of lymph node, occasionally pneumonia	Wild animals (in particular rabbits) and flies, eating infected animals	Skin, mouth, lungs	Approaches 0	Up to 40%	1-10 days (usually about 3-5 days)
PLAGUE Bubonic	High fever, may progress to pneumonia	Bite of infected flea; handling infected animal	Skin	Usually less than 10%	25-100%	2-6 days
PLAGUE (Continued) Pneumonic	High fever, cough	Inhaling organisms	Lungs	Properly treated, less than 50%	100%	1-4 days
CHOLERA	Nausea, vomiting, diarrhea	Water, food	Mouth	1%	15-90%	1-5 days
DIPTHERIA	Sore throat, followed by extreme fever, overall body infection	Direct contact with ill patient or carrier	Respiratory tract, skin	5-10%	10-15%	2-5 days; occasionally longer
TETANUS	Wound; spasm and increased muscle tone	Soil, dirt, feces	Wound	50-60%	80%	3 days to 3 weeks
TYPHOID FEVER	Fever, ulcers in intestines, diarrhea or constipation	Feces/urine of infected people	Mouth	2%	7-14%	6-21 days
EPIDEMIC TYPHUS	Headache, high fever, general pains	Infected person, lice	Skin	Usually less than 10%	10-40%	6-15 days
ROCKY MOUNTAIN SPOTTED FEVER	Fever, joint, muscle pains, skin rash	Infected ticks	Skin	Approaches 0	30-40%	3-10 days

Figure 16-5. Effects of Biological Agents (Sheet 1 of 2)

POSSIBLE AGENT	SYMPTOMS	SOURCE OF INFECTION	METHOD OF ENTRY	MORTALITY		TIME BETWEEN EXPOSURE AND SYMPTOMS
				TREATED	UNTREATED	
Q FEVER	Flu-like headache, fever, chest pains	Contaminated milk, dust	Lungs, mouth	Approaches 0	Less than 1%	2-3 weeks
ENCEPHALITIS & ENCEPHALOMYELITIS (many varieties)	Headache, fever, dizziness, convulsions	Mosquitoes, wild birds	Skin	1-40%	1-60%	4-24 days
SMALLPOX VARIOLA MAJOR	Severe fever, skin blisters and scabs; very contagious	Laboratory	Respiratory tract	20-35%	20-35%	10-14 days
YELLOW FEVER	Fever, headache, GI problems, jaundice	Blood from infected people; passed by mosquitoes	Skin	5-30%	30-40%	3-6 days
RIFT VALLEY FEVER	Fever, severe headache, joint pain, dizziness	Infected animals, mosquitoes	Skin, lungs	Usually 0	Less than 1%	4-6 days
RABIES	Fever, headache, nausea, nervousness	Bites from infected animals, inhalation of germs	Skin, lungs	99.9%	100%	10 days to 8 months (usually 50 to 60 days
DENGUE FEVER	Fever, chills, pain behind the eyes; most incapacitating, least fatal	Mosquitoes	Skin	Approaches 0	Approaches 0	4-10 days
COCCIDIOIDOMYCOSIS (Valley Fever)	Low fever	Dust, soil	Lungs	Approaches 0	Low, about 5%	10-21 days
HISTOPLASMOSIS	Skin lesions	Dust, spores	Lungs	Approaches 0	Less than 1%	5-18 days

Figure 16-5. Effects of Biological Agents (Sheet 2 of 2)

days. Decontamination of large areas is not feasible, but critical areas suspected of being contaminated can be decontaminated by the use of DS2 or a caustic soda solution.

16.3.4.1.3 Indoor Areas. Personnel in a shelter or building that is suspected of being contaminated with biological agents should wear their protective masks until the building is decontaminated or until they leave the contaminated area. Decontamination team personnel provide the support required for the interior decontamination of buildings.

16.3.4.2 Guard Against Contamination. Individuals must avoid food and water that could be contaminated. Microorganisms are difficult to detect; therefore, if a bilogical attack is suspected, all exposed surfaces must be assumed to be contaminated. Food and water in sealed containers may be consumed if the containers are boiled or washed thoroughly with soap and water before the seals are broken.

16.3.4.3 Report Sickness Promptly. Prompt reporting of sickness serves three purposes. First, it allows early treatment of the disease; second, it enables medical personnel to identify the biological agent to which individuals were

SUSPECT A BIOLOGICAL ATTACK IF–

- Low flying aircraft appear to produce a mist or spray.
- A munition is delivered by enemy aircraft that has no apparent explosive impact.
- Unusual bomblets are found.
- Numerous unexplained ill personnel are observed.
- Unusual swarms of insects are observed, such as mosquitoes, suddenly appearing after aircraft have dropped containers that do not have an immediate effect.
- Numerous sick or dying animals become apparent.

Figure 16-6. Signs of Possible Biological Attack

exposed; and, third, it helps prevent the spread of disease from person to person. Once the disease has been identified, effective medical measures can be taken.

16.3.4.4 Threat Casualties. Personnel who become ill because of a biological attack will be treated in the same way as patients are treated for illnesses resulting for normally transmitted diseases. The patients are transported to an aid station by medical aidmen and are evacuated to a hospital, if necessary.

16.4 CHEMICAL THREAT

The Threat Force has the capability to produce and deliver persistent and nonpersistent lethal chemical agents. Chemical agents — nerve, blood, and blister agents — may be used against aviation units to kill or incapacitate personnel and to contaminate aircraft, vehicles, and equipment.

Chemical munitions are available for surface-to-surface missiles, multiple rocket launchers, artillery, and aircraft munitions. Threat doctrine describes chemical agents as weapons available to the commander; Threat Forces are well equipped to use both offensive and defensive operations in a chemical environment. Additionally, Threat Forces have various chemical delivery means ranging from mortars to supersonic aircraft. These systems can deliver both persistent and nonpersistent agents either by airburst or surface burst, depending on the agent used.

16.4.1 Types of Chemical Agents. (See Figure 16-7.)

16.4.1.1 Nerve Agents. Nerve agents directly affect the nervous system and are highly toxic in liquid and vapor form.

16.4.1.1.1 Physiological Effects. Nerve agents interfere with the normal activity between the nervous system and muscles and organs of the body.

	TYPE OF AGENT	NERVE		BLISTER	BLOOD	CHOKING
	HOW NORMALLY DISSEMINATED	Aerosol or vapor	Liquid droplet	Liquid droplet	Vapor (gas)	Vapor (gas)
	MEANS OF DETECTION	Automatic chemical agent alarm and chemical agent detector kits to detect vapors and aerosols; chemical agent detector paper to detect liquids.				
	SYMPTOMS IN MAN	Difficult breathing, drooling, nausea, vomiting, convulsions, and sometimes dim vision.		Mustard, nitrogen mustard – no early symptoms; lewisite, mustard-lewisite – searing of eyes and stinging of skin; phosgene oxime – irritation of eyes and nose.	Convulsions and coma.	Coughing, choking, nausea, headache.
	EFFECTS ON MAN	Incapacitates; kills if high concentration is inhaled.	Incapacitates; kills if contaminated skin is not decontaminated rapidly.	Blisters skin; is destructive to respiratory tract; can cause temporary blindness. Some agents sting and form welts on skin.	Incapacitates; kills if high concentration is inhaled.	Damages and floods lungs.
	RATE OF ACTION	Very rapid by inhalation; slow through skin.	Delayed through skin; more rapid through eyes.	Blistering delayed hours to days; eye effects more rapid. Mustard lewisite and phosgene oxime very rapid.	Rapid.	Immediate to 3 hours.
INDIVIDUAL	HOW NORMALLY DISSEMINATED	Aerosol or vapor	Liquid droplet	Liquid droplet	Vapor (gas)	Vapor (gas)
	First Aid	Give nerve agent antidote injection. Artificial respiration may be necessary.		None.	Inhale amyl nitrite. Artificial respiration may be necessary.	For severe symptoms, avoid movement and keep warm.

Figure 16-7. Characteristics and Defense Against Types of Chemical Agents (Sheet 1 of 2)

TYPE OF AGENT		NERVE		BLISTER	BLOOD	CHOKING
INDIVIDUAL	DECONTAMINATION	None needed.	Flush eyes with water. Decontaminate skin using M258 kit.	Flsuh eyes with water. Decontaminate skin with M258 kit or soap and water.	None.	None.
PROTECTION REQUIRED		PROTECTIVE MASK AND CLOTHING		PROTECTIVE MASK AND CLOTHING	PROTECTIVE MASK	PROTECTIVE MASK
U.S. AGENTS EQUIVALENT	SYMBOL/NAME	GA/tabum GB/sarin GD/soman	VX Thickened G-agents.	HD/mustard HN/nitrogen mustard L/lewisite HL/mustard lewisite CX/phosgene oxime.	AC/hydrogen cyanide CK/cyanogen chloride.	CG/phosgene.
	FIELD CHARACTERISTICS	Colorless.		HD/HN– pale yellow droplets; mustard–dark droplets; HL/lewisite–dark, oily droplets; CX/phosgene–colorless droplets.	Colorless.	Colorless.

Figure 16-7. Characteristics and Defense Against Types of Chemical Agents (Sheet 2 of 2)

16.4.1.1.2 Symptoms. These include runny nose, tightness of the chest, difficult breathing, excessive sweating, drooling, nausea, vomiting, dimness of vision, pinpointing of the pupils, convulsions, and eventually death.

16.4.1.1.3 Characteristics. Nerve agents generally are odorless, colorless, and tasteless vapors or liquid. When inhaled, they are quick acting with some symptoms developing in 1 to 2 minutes after inhalation.

16.4.1.2 Blister Agents. Blister agents affect the eyes, lungs, and skin. Some are initially painless while others cause immediate burning or stinging sensations.

16.4.1.2.1 Physiological Effects. Blister agents cause chemical burns and blisters on all parts of the body that they contact. A droplet of a mustard-type agent the size of a pinhead may produce a blister 1 inch in diameter.

16.4.1.2.2 Symptoms. In addition to causing blisters on the skin, blister agents, when contacting the eyes, may cause redness, inflammation, and temporary or permanent blindness. If inhaled, blister agents can cause serious damage to mouth tissue, nose, throat, and lungs.

16.4.1.2.3 Characteristics. Some blister agents are odorless, while others have faint ordors. If used in droplet form, they range from colorless to a dark brown oily liquid.

16.4.1.3 Blood Agents. Blood agents usually are dispensed as vapors of aerosol and are inhaled.

16.4.1.3.1 Physiological Effects. They affect the respiratory and circulatory systems by preventing the use of oxygen in the blood by the body cells.

16.4.1.3.2 Symptoms. These include convulsions, leading to a coma. If a high enough concentration, death will occur.

16.4.1.3.3 Characteristics. They are colorless as gases but may have a faint odor.

16.4.1.4 Choking Agents. Choking agents are disbursed as vapors or aerosols and are ingested into the body by breathing.

16.4.1.4.1 Physiological Effects. They affect the respiratory process and cause death by dryland drowning.

16.4.1.4.2 Symptoms. These include coughing, choking, nausea, headache, cyanosis, gasping for breath, and a pinkish frothing from the mouth.

16.4.1.4.3 Characteristics. They are colorless in the gaseous form.

16.4.2 Individual Actions During a Chemical Attack. A chemical attack may come directly in the area in which individuals are located or upwind from that area. In either case, when an individual recognizes or is alerted to a chemical attack, he should take the following immediate defensive actions:

If not already masked, he should:

1. Put on his protective mask.
2. Give the alarm.
3. Continue the mission.

In addition, if the situation permits, he should take cover.

If symptoms of nerve agent poisoning appear, he should use appropriate nerve agent first aid.

If the skin or eyes are contaminated, he should decontaminate them.

If clothing and equipment are contaminated, he should decontaminate them as soon as the situation permits.

Any individual recognizing or suspecting a chemical attack should give the local alarm after masking, if not already masked.

16.4.3 Conditions Requiring Masking. If an attack is reported to be imminent or if chemical attacks have already been used by enemy forces, individuals not already masked should mask when:

1. Any artillery, mortar, rocket, or aircraft attack occurs on or near their position.
2. Smoke or mist of an unknown source arrives in the area.

3. A chemical attack is suspected for any other reason.

4. They or their unit must enter an area known to be, or suspected of being, contaminated with a chemical agent.

5. For no obvious reason, they see or feel any of the following symptoms:

(a) A runny nose

(b) A feeling of choking and tightness in the chest or throat

(c) Dimming of vision and difficulty in focusing the eyes on close objects

(d) Irritation of the eyes

(e) Difficulty in or increased rate of breathing.

16.5 M-24 MASK

The M-24 aviator protective mask (Figure 16-8) protects the aviator from inhaling vapors and aerosols of chemical, biological, and riot control agents. It does not protect the wearer from ammonia or carbon monoxide fumes. An M-2 anti-glare eye lens outsert is provided with the ABC M-24 mask since the sun visor of the protective flying helmet cannot be used with the mask. The mask can be attached to the aircraft oxygen supply system by the use of an M-8 adapter kit. Accessories include the M-7 aircraft protective mask hood and winterization kit. The hood is attached to the mask by the faceplate. For further discussion of the ABC M-24 mask, refer to TM 3-4240-280-10.

16.6 CHEMICAL PROTECTIVE CLOTHING

In a chemical environment, aviators and support personnel wear the chemical protective overgarment as their standard uniform. The nomex flight suit (or fatigues for support personnel) must be worn underneath. In addition, the M-7 protective hood is mounte on the M-24 protective mask. The hood may b worn over or under the aircrewman's helme depending on the mission. The protective mas with hood, protective overboots, and protectiv gloves complete the aviator's protective en semble. The protective garments protect per sonnel from liquid agents that penetrate th skin. Commanders of units on a chemical bat tlefield and those with a high threat of attac with chemical agents should have their aircrew flying in masks and overgarments, since rapi donning of the mask and protective clothin while flying is virtually impossible.

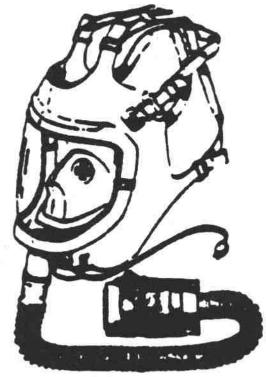


Figure 16-8. M-24 Mask

16.7 DETECTION AND DECONTAMINATION

Contamination from liquid chemical agent has the greatest impact on aviation operation Contaminated aircraft and vehicles must eithe be decontaminated or aviators and ground sup port personnel must operate in complete protec tive ensembles. Heat stress and task degradatio result from wearing protective equipmen Therefore, unit leaders must decide whether t decontaminate or accept performance degradation.

16.8 AIRCRAFT DECONTAMINATION

Adapting measures that prevent the contamination of the interior of the aircraft (Figure 16-9) will greatly reduce the time and effort required to decontaminate the aircraft. Aircraft may become contaminated by enemy spray attacks, bombs, shells, or rockets, or while performing a spray mission. Contamination may occur during spray missions by leaking chemical tanks or by the slipstream carrying the spray against the aircraft. Due to the requirement for proper maintenance of the aircraft, personnel may come into physical contact with contaminated surfaces. If the aircraft is lightly contaminated by spray, it may be decontaminated by aeration. Flying the aircraft is a method of aerating the outer surface. A major problem in the decontamination of aircraft is the requirement to avoid the use of decontaminants that remove paint, corrode the surface of the aircraft skin, etch plastic cockpit covers, or damage flight control mechanisms. Normally, NBC units, with assistance from the aviation unit, will be used to wash and rinse aircraft since they have specialized equipment. However, when NBC units are not available, aviation units may have to use field expedients to partially decontaminate aircraft in order to continue combat operations. Upon determination that the aircraft is contaminated, the type of agent should be identified. If the interior of the aircraft has been contaminated, blow compressed air on equipment that water will damage. Wash remaining surfaces with warm soapy water, and repeat washing several times. Rags used during this phase are contaminated. Properly dispose of all rags used. Fabric seats, floor coverings, curtains, safety belts, etc., should be replaced. If the exterior of the aircraft is contaminated with thickened agents, the following procedures should be followed:

1. Move the aircraft to a nonoperational area and apply supertropical bleach (STB) slurry or dry mix (two parts STB to three parts earth, sand, or ashes) to the ground beneath the aircraft.

WARNING

Full strength STB reacts violently with liquid mustard producing a fire. Fires can be prevented by diluting STB with water to form a slurry. Particular care must be taken to keep STB and DS2 off the aircraft.

2. Prepare a hot solution of 300 gallons of water in the M12A1 power-driven decontaminating apparatus (PDAA) or other suitable container, 20 kilograms (kg) (44 pounds) of GI soap, and 10 kilograms (22 pounds) of washing soda. Add water to make 400 gallons.

3. Spray this solution to the outside surface of the aircraft using a fan-shaped spray under reduced pressure. Scrub the contaminated surfaces with medium-stiff, long-handled brushes, taking special care to wash thoroughly those areas and parts that require intensive hands-on type of maintenance.

4. After the aircraft has been washed thoroughly, rinse all exterior surfaces with hot water (refer to the appropriate aircraft maintenance manual for maximum allowable cleaning solution temperature). Hold the nozzle at least 1 meter (3 feet) from the surface in such a manner that the spray strikes away from the operator at about a 45° angle. Use reduced pressure and a fan-shaped spray on transparent surfaces, e.g., windows and canopies.

5. Decontaminate tires with STB slurry. Replace heavily contaminated tires with clean tires.

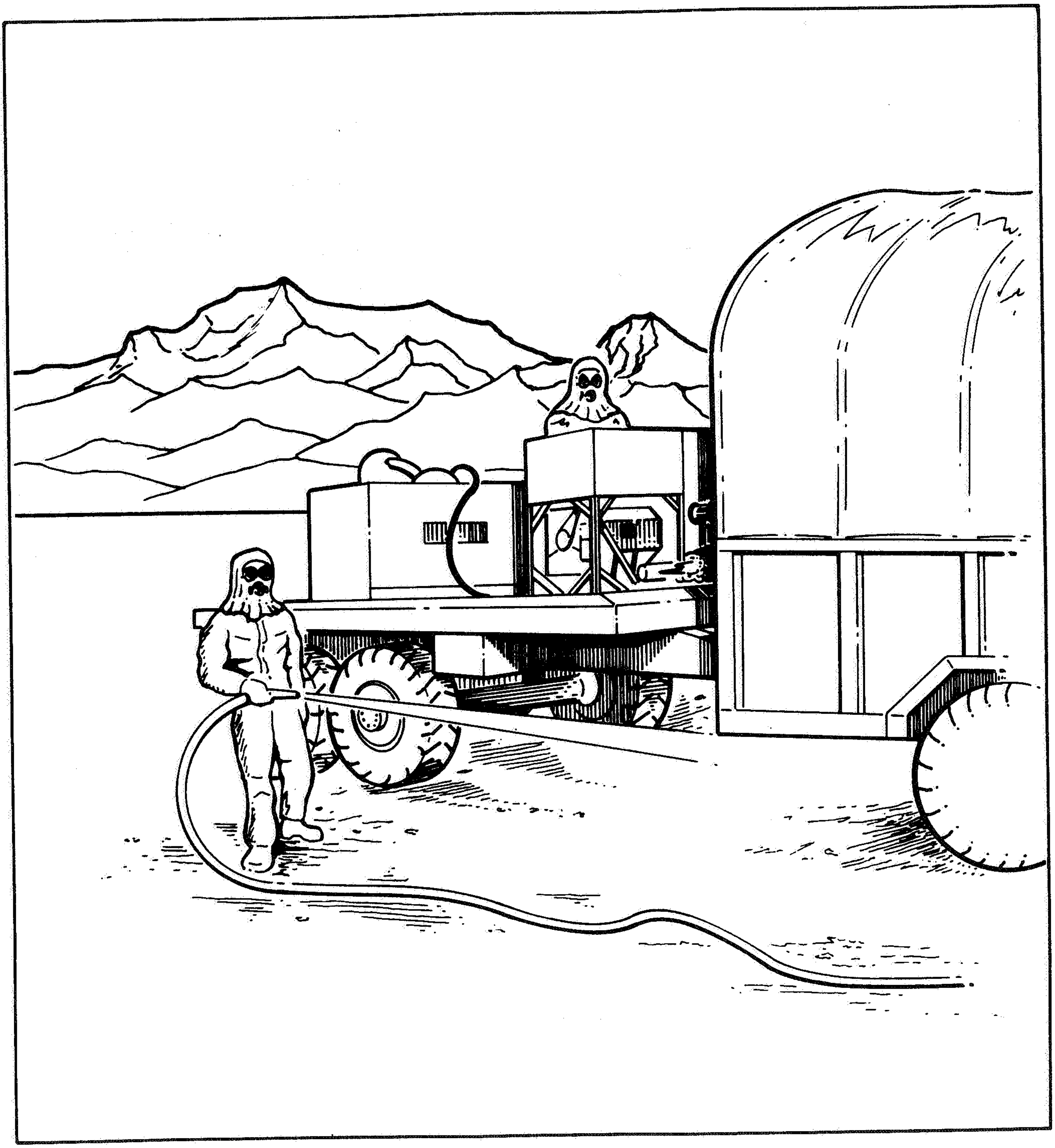


Figure 16-9. Aircraft Decontamination

6. After decontamination, move the aircraft, if not required for immediate use, to an uncontaminated area for aeration. If the aircraft is required for immediate use, it should be flown to assist in removing any external contamination overlooked during the wash and rinse cycles.

Except for the use of STB on aircraft tires, neither STB nor DS2 is to be used as a decontaminant on aircraft. Aircraft, while parked on airfields or in revetments, should be covered with some type of protective material to prevent contamination by spray attack. Tarpaulins offer best results as they can be decontaminated by washing with STB slurry and rinsing with clear water.

16.9 PERSONNEL DECONTAMINATION

Aircraft members and ground support personnel contaminated by liquid chemical agents perform emergency and partial decontamination procedures as described in TM 3-220. If vapor hazards continue to be released from individual clothing, complete personnel decontamination is scheduled when time and mission permit. Complete personnel decontamination is conducted at a personnel decontamination station operated by NBC units as described in FM 3-87 and FM 3-5. Full protective ensemble must continue to be worn as long as vapor hazards are present or until complete personnel decontamination is accomplished.

16.10 SUMMARY

Aviation personnel, both flight and ground support, must be constantly aware of the impact that the use of NBC weapons can have on their operations. Threat Forces can be expected to employ NBC weapons when it is to their advantage to do so. The adverse impact of Threat NBC use can be minimized by proper use of NBC defensive equipment and operational procedures and by meaningful training in a simulated NBC environment.

APPENDIX A

Aircraft Limitations

A.1 INTRODUCTION

The limitations set forth in this appendix are the direct result of flight test programs and actual operational experience. Compliance with these limits will provide for the maximum utilization of helicopters and crew to perform assigned missions.

A.2 ACCELERATION LIMITATIONS

A.2.1 Turn Versus g-Load. During constant airspeed maneuvering turns, an increased g-load, which varies with the angle of bank, is exerted on the helicopter. For instance, a 30° bank will produce 1.15g, a 45° bank 1.4g, a 60° bank, 2.0g's. This means that during a 60° bank, the rotor must furnish 2g's or lift equal to twice the weight of the helicopter in order to maintain that angle of bank.

A.2.2 Transient Torque. Transient torque, although evident in all semirigid single rotor systems, is a phenomenon which is quite pronounced. With a rapid application of left lateral cyclic, a rapid torque increase followed by a decrease will be evidenced. This condition occurs as a result of temporary increased induced drag being placed on the rotor system by the additional pitch in the advancing blade. With a rapid application of right lateral cyclic, a rapid torque decrease followed by an increase will be evidenced. This condition occurs as a result of drag being reduced in the rotor system due to the reduction of pitch in the advancing blade, which temporarily decreases the blade's resistance to the air flow.

CAUTION

- During left rolling maneuvers or high power dives, torque, ITT, and N_g increases occur. Care should be exercised in monitoring instruments to enable the pilot to reduce power as required to prevent exceeding limits.
- During right maneuvers rotor RPM increases will occur proportionally to control inputs. Care should be taken not to exceed rotor RPM limits.

Increasing and decreasing rotor system drag will produce corresponding torque changes because the rotor system's requirement for an increase or decrease in power is sensed and subsequently supplied by the fuel control system. As airspeed and severity of the maneuver are increased, the transient torque effect is also increased. The pilot should become familiar with this characteristic and form a natural tendency to compensate with collective control to avoid exceeding the aircraft torque and rotor rpm limitations.

A.2.3 Maneuvering Flight. When performing above 120 knots, it is necessary to devote more attention to flying and to planning maneuvers because of the increased distance needed to perform pullouts and turns. The increased distance required for pullouts and turns is a direct result of the higher airspeed.

A.2.4 Radius of Turn. At airspeeds above 120 knots, the radius of turn and rate of closure increase rapidly. The turn radius is a function of the bank angle and the square of the airspeed. For any given condition of altitude and weight, where the g capability is defined by rotor characteristics, the turn radius can be markedly affected by airspeed. The effect of speed can be ascertained by an inspection of Figure A-1. From the examples A and B, it can be seen that for a bank angle of 30°, the radius of turn is increased by a factor of four when the airspeed is increased from 80 to 160 knots. Figure A-2 provides a graphic chart of the turning radius in relationship to airspeed.

A.2.5 Low g Maneuvers. Because of mission requirements, it may be necessary to rapidly lower the nose of the aircraft in order to acquire a target, maintain target tracking/firing solution or to avoid undesirable aircraft silhouetting. At moderate to high airspeeds, it becomes increasingly easier to approach zero or negative load factors by abrupt forward cyclic inputs. The helicopter may exhibit a tendency to roll to the right simultaneously with the forward cyclic input. This tendency is more pronounced with the SCAS disengaged.

WARNING

- The following airframe g-limits apply to the AH-1J:
  10,000 lb gross weight: 0.5 to 1.56g
  8,500 lb and below: 0.5 to 2.25g
- The following airframe g-limits apply to the AH-1T:
  14,000 lb gross weight: 0.5 to 2.5g
  10,000 lb and below: 0.5 to 3.5g

Such things as sideslip, weight and location of wing stores, and airspeed will affect the severity of the right roll. Variances in gross weight, longitudinal CG, and rotor rpm may affect the roll characteristics. The right roll occurs throughout the normal operation airspeed range and becomes more violent at progressively lower load factors.

WARNING

If an abrupt right roll should occur when rapidly lowering the nose, pull in aft cyclic to stop the rate and effect recovery; left lateral cyclic will not effect recovery from a well-developed right roll during flight at less than 1g and it may cause severe main rotor flapping. Do not move collective or directional controls or disengage the SCAS during recovery.

Note

When it is necessary to rapidly lower the nose of the aircraft, it is essential that the pilot monitor changes in roll attitude as the cyclic is moved forward.

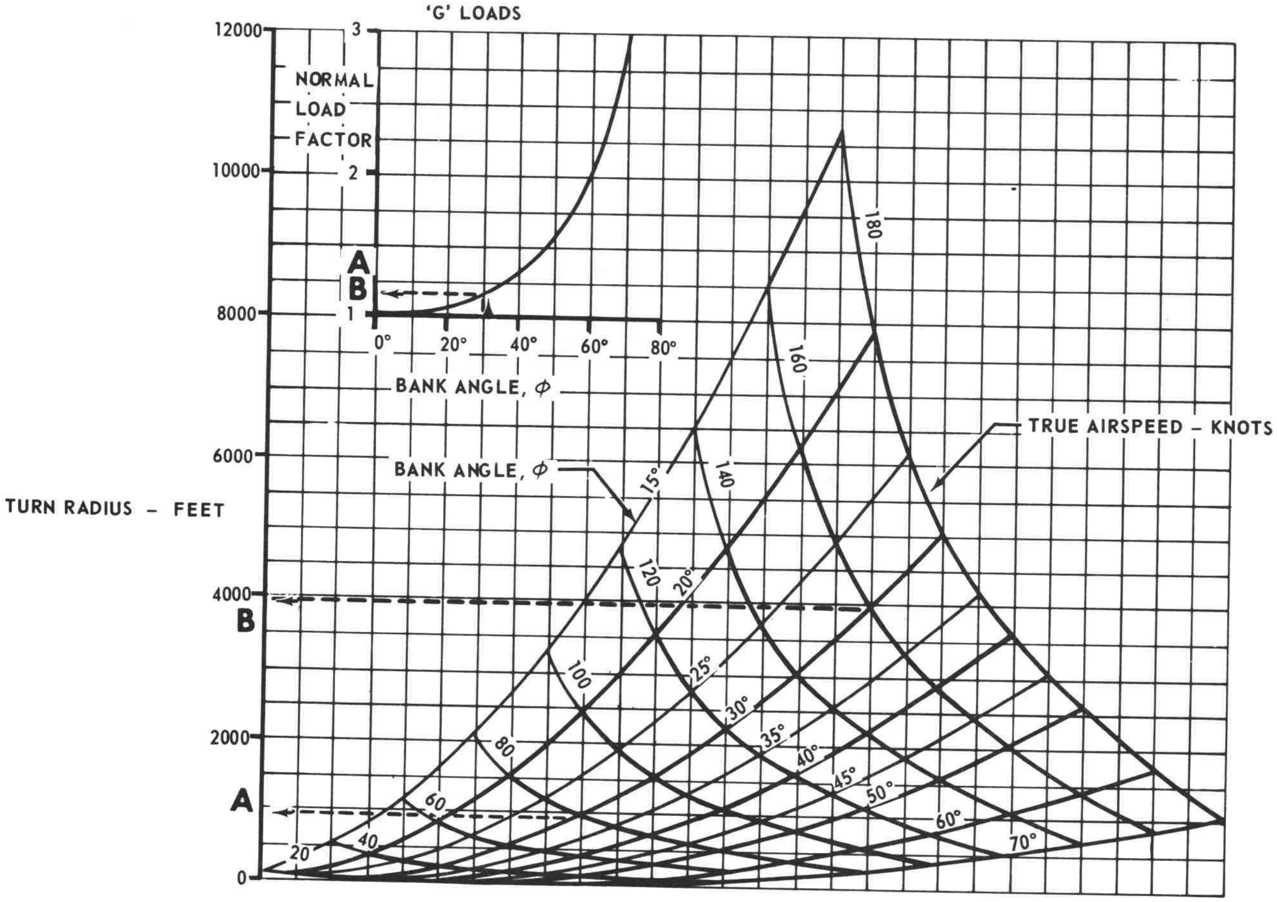
A.2.6 Diving Flight. Diving flight presents no particular problems; however, the pilot should have a good understanding of such things as rates of descent versus power. Refer to Figure A-3. Because of relatively low drag, the aircraft gains airspeed quite rapidly in a dive and it is fairly easy to exceed the redline. Rates of descent of 3,500 ft/min to 4,800 ft/min are not uncommon during high speed dives. These high rates of descent, coupled with the high flightpath speeds, require that the pilot monitor both closure rate and terrain features very closely to preplan his recovery to avoid having to initiate a late/abrupt recovery. If an abrupt recovery is attempted at speeds near redline airspeed, mushing of the aircraft can occur. If mushing is experienced, do not increase collective. Application of increased collective will aggravate condition. Figure A-3 depicts the altitude lost during a pull out versus rate of descent for various g-loadings.

A.3 EXTERNAL STORES LIMITATIONS

Only those weapons/stores authorized for carriage and release from AH-1J/T aircraft are depicted in Figure A-4.

TURN RADIUS = $\frac{v^2}{g \tan \phi}$ NORMAL LOAD FACTOR = $\frac{1}{\cos \phi}$

Note This chart gives the turn radius in feet as a function of airspeed and either bank angle or normal load factor. The capability of the aircraft is not inferred by this chart, but trade-off of bank angle versus turn radius are valid.



EXAMPLE A

AIRSPEED - 80 KTAS
BANK ANGLE - 30 DEGREES

SOLUTION:
TURN RADIUS - 981 FEET
'G' LOAD - 1.15

EXAMPLE B

AIRSPEED - 160 KTAS
BANK ANGLE - 30 DEGREES

SOLUTION:
TURN RADIUS - 3925 FEET
'G' LOAD - 1.15

Figure A-1. Radius of Turn

Note

This chart gives the turn radius in feet as a function of airspeed and either bank angle or normal load factor. The capability of the aircraft is not inferred by this chart, but trade-off of bank angle versus turn radius are valid.

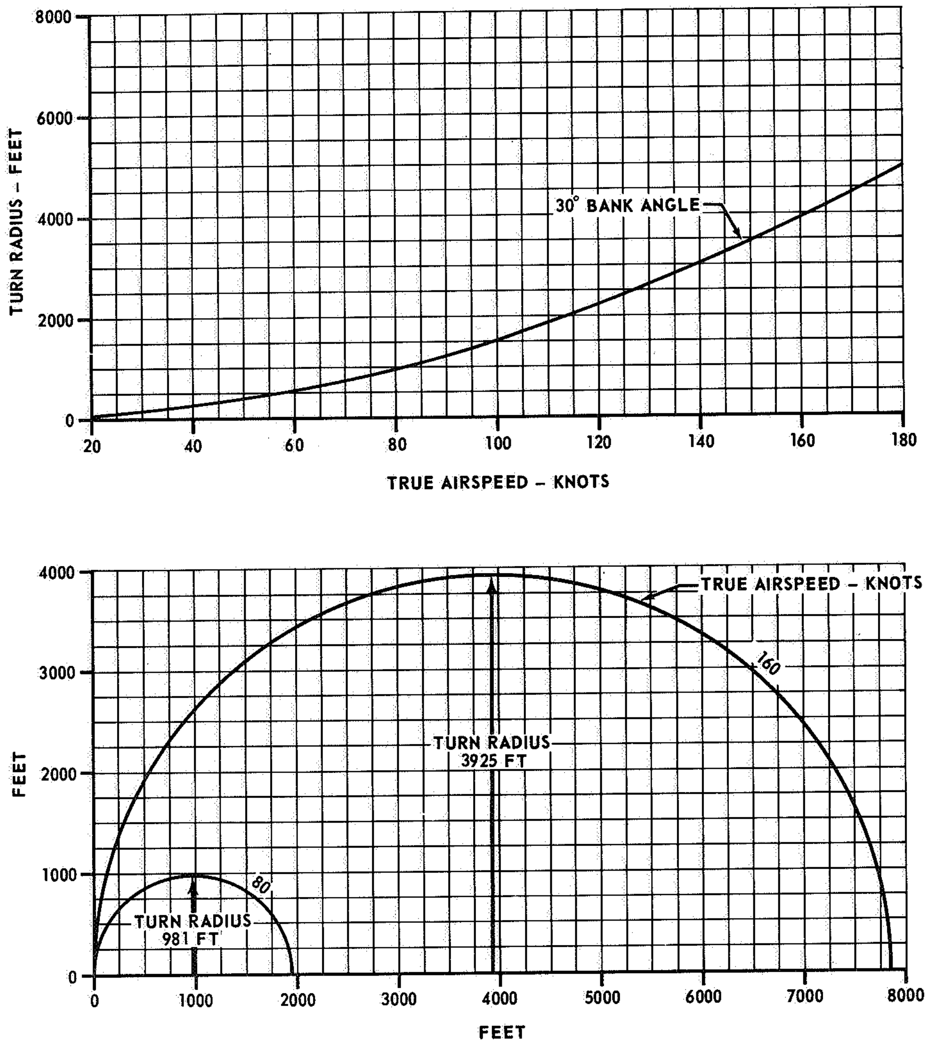


Figure A-2. Turn Radius

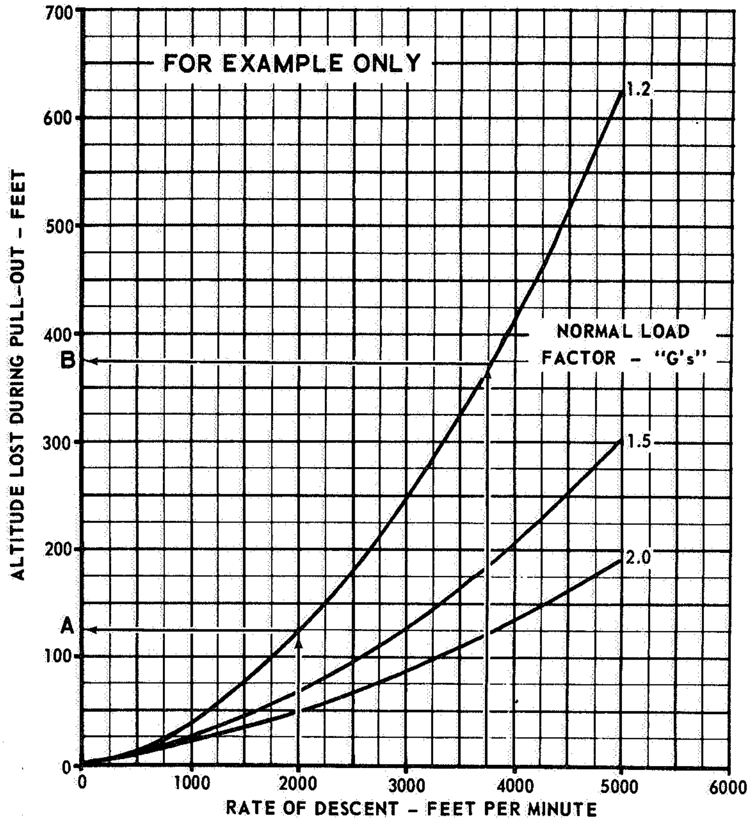
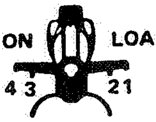


Figure A-3. Dive Recovery

STATION LOADING



NOTES 1 thru 6 apply for all stores configurations

LOAD NR	OUTBOARD STATIONS 1/4	INBOARD STATIONS 2/3									
		LAU-61A/A, B/A, C/A RKT LAUNCHER (SEE NOTES 3, 7, 9, AND 10)	LAU-68B/A, D/A RKT LAUNCHER (SEE NOTES 3, 9, AND 10	LAU-10C/A, D/A RKT LAUNCHER (SEE NOTES 3 AND 10)	GPU-2/A GUN POD (SEE NOTE 16)	SUU-44/A, 25 F/A DISPENSERS (SEE NOTES 11 AND 12)	CBU-55B, A/B FAE (SEE NOTE 13)	MK 77 MOD 2/4 FIRE BOMB (SEE NOTE 14)			
1	SINGLE TOW MISSILE LAUNCHER (TML) (SEE NOTE 7 AND 8)	●	●			●					
2	DUAL TOW MISSILE LAUNCHER (TML) (SEE NOTES 7 AND 8)	●	●			●					
3	LAU-61 A/A, B/A, C/A RKT LAUNCHER (SEE NOTES 3, 9, AND 10)	●	●	●		●					
4	LAU-68 B/A, D/A RKT LAUNCHER (SEE NOTES 3, 9 AND 10)	●	●	●	●	●	●	●			
5	LAU-10 C/A, D/A RKT LAUNCHER (SEE NOTES 3, 10, AND 18)	●	●	●		●	●				
6	SUU-44/A, 25 F/A DISPENSERS (SEE NOTES 11 AND 12)	●	●	●		●	●				
7	M118 GRENADE LAUNCHER	●	●	●	●	●	●	●			
8	CBU-55B, A/B FAE (SEE NOTE 13)		●	●		●	●				
9	MK 77 MOD 2/4 FIRE BOMB (SEE NOTE 14)		●	●		●					
10	PRAC BOMBS: MK 76 MOD 5, BDU-33D/B MK 106 MOD 5, BDU-48/B (SEE NOTE 15)		●	●		●					
11	100 GALLON FUEL TANK (SEE NOTES 8 AND 17)	NO INBOARD STORES AUTHORIZED									
12	AIM-9H, L, M SIDEWINDER (SEE NOTES 19 AND 20)		●	●		●					
13	TACTS POD TSQ-13, -17, -18 (SEE NOTE 21)		●	●		●					

● INDICATES AUTHORIZED STORE COMBINATION FOR EITHER WING; ASYMMETRIC LOADING OF ANY OF THE ABOVE COMBINATIONS IS AUTHORIZED PROVIDED THE LATERAL CG LIMITS (6" L OR R) ARE NOT EXCEEDED.

Figure A-4. AH-1J/T External Stores Limitations (Sheet 1 of 3)

NOTES

1. Definitions:

   a. PMBR: Practice Multiple Bomb Rack, A/A37B-3
   b. TML: Tow Missile Launcher
   c. LBA: NATOPS Limits of the Basic Aircraft
   d. OGE: Out of Ground Effect

2. Carriage and release airspeed and g limits are the NATOPS limits of the basic aircraft (LBA) unless otherwise noted. The maximum release/fire dive angle is 30° unless otherwise noted. Recommend jettison in emergency only in +1.0g level flight between 80-120 knots.

3. Simultaneous deployment/firing of stores from adjacent stations is prohibited.

4. Plan bomb/rocket release at adequate slant range to avoid blast/fragment damage to delivery aircraft or aircraft in formation with the release aircraft.

5. The Mk 149 Mod 0 armor piercing discarding SABOT ammunition is authorized for use in the Mk 197/GTU-1A and GTK-4A/A gun in the lower stowed position (zero degrees azimuth and elevation) to the limits of the basic aircraft.

CAUTION

Use of the Mk 197 gun with the Mk 149 ammunition in any gun position other than the lower stowed position could cause substantial damage to the aircraft by firing the discarding SABOT into the main rotor blades or flying into the aluminum pusher.

6. The ALE-39 expendable countermeasures dispenser loaded with either RR-129 or RR-144 chaff or Mk 46/MJU-8/B decoy flares is authorized for use to the limits of the basic aircraft and any external stores configuration.

7. TML must be jettisoned prior to jettison of adjacent LAU-61 RKT launcner.

8. AH-1T aircraft only.

9. MK 4 motors may be used if MK 40/66 motors unavailable.

10. RKT launcher mode select switch must be set on SINGLE.

11. SUU-44/A, -25 F/A Dispenser:

    a. SUU-44/A is authorized to carry Mk-45, LUU-2A/B, and LUU-2B/B parachute flares.

    b. SUU-25 F/A is authorized to carry LUU-2B/B parachute flare ONLY.

    c. LUU-2A/B flare authorized for land-based use ONLY.

    d. LUU-2B/B flare authorized for land and shipboard use.

12. Maximum deployment dive angle is 0°.

Figure A-4. AH-1J/T External Stores Limitations (Sheet 2 of 3)

13. CBU-55B, A/B:

    a. Loaded on stations 1/4 – Inboard fins must be closed when adjacent station is loaded.

    b. Loaded on stations 2/3 – Outboard fins must be closed when adjacent station is loaded.

    c. Minimum release airspeed is 75 KIAS.

14. Fuzing not authorized for use with MK 77 Mod 2/4 Fire Bomb.

15. Practice bombs/PMBR:

    a. PMBR is ONLY AUTHORIZED method of carriage.

    b. Mixed loading of Mk-76, Mk-106, BDU-33, and BDU-48/B on the same PMBR is authorized provided different types are not released on the same target run.

    c. DO NOT LOAD inboard shoulder stations.

16. GPU-2/A gun pod: Max jettison speed is 155 KIAS; firing g limits are +0.7g to +3.0g.

17. Jettison envelope for 100 gallon fuel tank:

    a. Autorotation: Max airspeed – 120 KIAS; Max sideslip – half ball.

    b. Level flight: Max airspeed – 150 KIAS; Max sideslip – half ball.

    c. 30° dive: Max airspeed – 175 KIAS; Max sideslip – half ball.

18. Firing rate must be set on slow.

19. This note applies to the AH-1J aircraft only:

    a. No inboard stores authorized.

    b. No jettison allowed. No eject or cartridges to be installed.

20. This note applies to the AH-1T aircraft only.

    a. When carrying adjacent stores, the jettison selector must be in the all position to ensure proper delay between inboard and outboard stores during jettison.

    b. Recommend jettison in emergency only in +1.0g level flight, less than 130 KCAS.

21. Jettison is not authorized.

Figure A-4. AH-1J/T External Stores Limitations (Sheet 3 of 3)

APPENDIX B

Airborne Control Techniques

B.1 TACTICAL AIR COMMAND CENTER (TACC)

The TACC is the principal United States Marine Corps air operation installation from which aircraft and air warning functions of tactical air operations are directed. It is the senior agency of the Marine Corps air command and control system from which the Marine Corps tactical air commander can direct and control tactical air operations and coordinate such air operations with other services. (The naval counterpart is the tactical air control center.)

B.2 TACTICAL AIR DIRECTION CENTER (TADC)

The TADC is identical in organization to the TACC, but the TADC carries out only those functions delegated to it by the TACC. When the landing force TADC (ashore) is capable of assuming control, and when ordered by the ATF, the landing force TADC becomes the TACC (ashore) and assumes control of all air operations in the objective area. Simultaneously, the TACC (afloat) becomes a TADC, responsible to the TACC (ashore) for whatever functions are assigned to it. When it becomes necessary to organize the amphibious task force into subordinate task groups, a TACC may employ a TADC for control of air operations in a specific area. Overall control is retained by the CATF through the task force TACC.

B.3 TACTICAL AIR OPERATIONS CENTER (TAOC)

The TAOC is a subordinate operational component of the air control system designed for control and direction of antiair warfare (AAW) operations in assigned air sectors. The mission of the TAOC is to detect, identify, and control the intercept of hostile aircraft and missiles and to provide navigational assistance to friendly aircraft in the accomplishment of support missions. Each Marine air control squadron (MACS) will furnish one TAOC.

B.4 DIRECT AIR SUPPORT CENTER (DASC)

The DASC is the principal air control agency subordinate to the TACC (ashore) for the control of close air support and assault support operations. The DASC is equipped and operated by the Marine air support squadron (MASS). The DASC coordinates close air support missions controlled by TAC(A), (forward air controller (airborne) (FAC(A)), FAC, and the air support radar teams (ASRT). It is the first major air support control facility established ashore during an amphibious operation. The DASC is normally collocated with the FSCC of the major ground combat command element. Control of close air and assault support operations may be passed ashore when the DASC becomes operational and when directed by the ATF. This will often be in advance of the general passage of all control ashore.

B.5 AIR SUPPORT RADAR TEAM (ASRT)

The ASRT is a terminal air support control agency subordinate to the DASC which provides precision aircraft control during all-weather/night operations. The ASRT employs a radar bomb directing set (TPB-1D) which consists of a precision radar and associated computer equipment designed to accurately position aircraft without visual reference to the Earth's surface. There are three ASRTs organic to the

Marine Air Support Squadron of the Marine Air Control Group.

B.6 FIRE SUPPORT COORDINATION CENTER (FSCC)

An FSCC is located with each maneuver unit headquarters at the battalion level and higher. It is staffed by the fire support coordinator (FSC) and representatives from each of the maneuver units supporting arms. The FSCC functions primarily to facilitate the rapid engagement of targets and ensure troop safety. The highest level FSCC is collocated with the DASC.

B.7 TACTICAL AIR CONTROL PARTY (TACP)

The TACP is the aircraft control element serving as the point of contact between the air and ground elements of the Marine Air Ground Task Force (MAGTF). Each TACP is trained and equipped to provide the necessary communications, liaison, advice, and direction of air support missions for the LFC. In each Marine division there are 13 TACPs: one at the division command post and one at each regimental and battalion headquarters.

B.8 FORWARD AIR CONTROLLER (FAC)

The FAC advises the unit ground commander on all matters pertaining to aviation and maintains positive ground-air-radio communications which gives him the capability to control close air support air strikes. There are three NA/NFOs in the battalion TACP. The senior NA/NFO is the air officer and the other two NA/NFOs are the leaders of the forward air control (FAC) parties.

B.9 CLOSE AIR SUPPORT

When artillery and naval gunfire are inappropriate or are out of range, targets are neutralized or destroyed by strike aircraft. Close air support (CAS) refers to air attacks against hostile targets in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces. The commander of the supported ground unit requests and/or approves all close air support missions in his area of responsibility. Deep air support missions require no coordination with friendly ground units and generally will not be controlled. This section deals with the planning procedures required to conduct close air support (CAS). For a general discussion of the capabilities and limitations of CAS, refer to FMFM 5-1, Chapter 1 and OH 5-4.1 (CAS Handbook). The two categories of CAS missions are:

B.9.1 Preplanned Missions. Preplanned missions are those requested sufficiently in advance to permit completion of detailed plans and briefing of aircrews prior to takeoff.

B.9.2 Immediate Mission. An immediate mission is an air strike on a target which could not be identified sufficiently in advance to permit detailed mission coordination and planning. Response time, or the action cycle beginning with the request and terminating with the attack, is the prime consideration. Immediate missions are executed in response to requests by ground commanders to strike unforeseen targets. Requests for an immediate mission originates with the FAC and is passed to the DASC via the Tactical Air Request (TAR) net. This transmission is monitored by the cognizant FSCCs and their silence implies concurrence of the request. Details for the mission are coordinated and promulgated while aircraft are being assigned and are en route to the target.

B.10 STRIKE AIRCRAFT CAPABILITIES

A thorough knowledge of the capabilities of the aircraft the FAC(A) or TAC(A) will control is essential to the success of his mission. Figure B-1 depicts the communication, navigation, ordnance, and delivery capabilities of attack aircraft in the Marine Corps inventory.

ACFT TYPE	RADIOS		CONVENTIONAL ORDNANCE TYPES,		MAX	DELIVERY MANEUVERS[1]	INFO REQD FROM
	COMM	NAV	GUNS	EXT	LOAD	TYPE	FAC(A)
A-4M	UHF VHF-FM	Tacan ADF	20 mm 400 rds	All	8,000	Dive/Toss Loft[2]	Visual Mark IP, Magnetic Heading, Distance to Target (nm)
AV-8A/C	UHF VHF-FM	Tacan	30 mm 260 rds	All Except Mk 84, Walleye, Elec. Fzd Ordnance		Dive	IP, Magnetic Heading, Distance to Target (nm) Visual Mark
AV-8B	UHF VHF-FM VHF-AM	Tacan INS	25 mm 300 rds	All		Dive/Toss Loft[2]	IP, Magnetic Heading, Distance to Target (nm) Visual Mark
A-6E	2 UHF	Tacan UHF/ADF Radar/INS Computer CAINS		All Except Walleye	15,000	Boresight[3] Radar Offset[3] Beacon Offset[3] AMTI[3 4]	Visual Mark Radar pt Beacon; Location (Lat/Long), Elevation Target; Bearing (true) Distance (ft), Elevation Location, (direction of movement)
AH-1J	UHF VHF-FM	Tacan UHF/ADF ADF/NDB FM Homer Radar Beacon	20 mm 750 rds	2.75-Inch FFAR Flares CBU-55 5.00-Inch FFAR	1,100	Hover Running Fire	AP, Mag Hdg, Distance to Target (meters)
AH-1T	VHF-FM UHF	UHF/ADF ADF/NDB FM Homer Radar Beacon Tacan	20 mm 750 rds	2.75-Inch FFAR Flares CBU-55 TOW 5.00-Inch FFAR	2,500	Hover Running Fire	AP, Mag Hdg, Distance to Target (meters)

Figure B-1. Marine Attack Aircraft (Sheet 1 of 2)

ACFT TYPE	RADIOS		CONVENTIONAL ORDNANCE			DELIVERY MANEUVERS[1]	
	COMM	NAV	GUNS	TYPES, EXT	MAX LOAD	TYPE	INFO REQD FROM FAC(A)
F4/N/S	UHF UHF Aux Rec	Tacan UHF/ADF Radar Computer (Nav.)		All except Mk 84, Walleye	12,000	Dive Loft[2]	IP, Magnetic Heading, Distance to Target (nm) Visual Mark
OV-10	UHF 2 VHF–FM HF	Tacan UHF–ADF FM–ADF FM Retrans	7.62 mm 2000 rds or 20 mm POD	2.75-Inch FFAR 5.0-Inch FFAR CBU-55 FLARES	3,600	Dive/Toss/	IP, Magnetic Heading, Distance to Target (nm) Visual Mark
F/A-18	UHF VHF–FM VHF–AM	Tacan INS Radar	20 mm 578 rds	All	17,000	Dive Toss Loft	Visual Mark Visual Mark (Lat/Long), Elevation
A7-E	UHF	Tacan Radar ADF Inertial Doppler	20 mm 1019 rds	All	12,000	Boresight Radar Offset Loft Dive/Toss	Visual Mark Radar pt Beacon; Location (Lat/Long), Elevation IP, Mag Heading, Distance to Target (nm) Bearing Distance
OA-4	2 UHF VHF–FM	Tacan UHF-ADF	20 mm 400 rds	All	7,000	Dive/Toss Loft[2]	IP, Magnetic Heading, Distance to Target (nm) Visual Mark

NOTES:
1 All aircraft can perform visual and pop-up attacks when given to standard or the pop-up brief.
2 The attack pilot must preplan loft deliveries.
3 Attack may be level, dive or toss.
4 Airborne moving target indicator (AMTI).
5 The A-7E is a USN aircraft which is most likely to support Marine units.

Figure B-1. Marine Attack Aircraft (Sheet 2 of 2)

The system available on each of these aircraft has a measurable effect on the circular error probable (CEP) of the delivery, and this in turn affects the number of sorties required to neutralize or destroy the target. The classified Joint Munitions Effectiveness Manual (JMEM, FMFM 5-2 series) provides average CEPs for specific weapons and aircraft systems. The FAC(A) or TAC(A) should have a general knowledge of this material, but must also use his own experience to evaluate how weather, terrain, enemy defenses, and pilot skill will affect the data.

B.11 AIRBORNE ORDNANCE CAPABILITIES

B.11.1 Weapons Description

1. LDGP bomb (Mk 80 series) includes fragmentation patterns and Snakeye bomb

2. Laser guided bomb (LGB)

3. Fire bomb (Mk 77)

4. Walleye I and II

5. Rockeye (Mk 20)

6. APAM (CBU-59)

7. Maverick — attack aircraft may also carry cannons, rockets, and fuel-air explosives (FAE).

B.11.2 Weapon Selection. Matching the appropriate weapon with the target is one of the key responsibilities of the FAC(A). Appropriate selection guarantees an effective strike and precludes needless risk for both the aircrews and the supported ground unit. A general guide to weapon selection is found in Figure B-2. For preplanned strikes, more detailed information is found in the JMEMs.

B.11.3 Minimum Safe Distances. The recommended minimum safe distances from friendly troops in Figure B-3 assumes flat terrain. In some cases, closer delivery can be made if terrain (friendly cover) permits or if the tactical situation is urgent. The FAC(A) shall inform the ground unit commander of the risks involved prior to commencing such a strike.

B.12 ATTACK PATTERNS

In addition to understanding attack aircraft ordnance capabilities, the FAC(A) and TAC(A) must know the standard ordnance delivery maneuvers, and the advantages and limitations of each (Figures 6-12 through 6-15).

B.12.1 Racetrack Attack Pattern. The racetrack pattern offers the best safety margin to friendly forces. It is the easiest pattern to control since it provides a predictable roll-in point to aid the FAC(A) in acquiring the attack aircraft on each pass and, also, provide a consistent reference line for corrections on repeated runs. However, the rigidity of the pattern offers little latitude for evasive maneuvering of the attack aircraft. Pattern variations might include a 180° change in run-in heading, and the consequent reversal in pulloff direction, after several runs on the original heading.

B.12.2 Wagonwheel Attack Pattern. The wagonwheel pattern provides greater flexibility and safety to the fixed-wing aircraft than does the racetrack pattern, but is much more difficult for the FAC(A) to control. This pattern is normally employed in an area of high enemy threat and not in close proximity to friendly ground units. In the wagonwheel pattern, attack is initiated on the target from a circle having the target at its center. The lead aircraft rolls in, calling his heading, and the wingman rolls in 40° to 60° farther along the circle, also calling his attack heading. The leader pulls up and joins the cycle to proceed farther along to repeat the same procedure. This ensures that no two successive attacks on the target will be from the same direction and helps to confuse enemy gunners. Because of unpredictable roll-in direction and faster airspeed

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
1. Personnel			
a. In Open	Chemical Weapons		
	Cluster Weapons with Fragmentation Bomblets		
	Firebombs		
	General Purpose Bombs	Instantaneous & V.T.	
	H.E. Gun Projectiles		
b. In Foxholes	Chemical Weapons		
	Cluster Weapons with Fragmentation Bomblets		
	Fuel-Air-Explosives		
	General Purpose Bombs	V.T.	
c. Under Light Cover	Chemical Weapons		No Guided Weapons Due to Limited Signature
	Cluster Weapons with Shaped-Charge Bomblets		
	Fuel-Air-Explosives		
	General Purpose Bombs	Short Delay	
	Rocket or Gun Projectiles with Armor Piercing Warheads		
d. Under Heavy Cover (Concrete Bunkers)	General Purpose Bombs	Long Delay	
	Guided Weapons with Large Warheads		
	Tow		
	Hellfire		
2. Armored Vehicles (Tanks, APC's & Mobile Assault Guns)	Conical-Shaped-Charge (CSC) Weapons		
	Electro-Optically-Guided Bombs (EOGB's)		
	General Purpose Bombs	Instantaneous or Short Delay	
	Guided Weapons with LSC Warheads		
	LGB's		
	Rockets with Armor Piercing Warheads		
	Tow		
	Hellfire		
3. Field Artillery			
a. In Open	Cluster Weapons with CSC Bomblets and Fragmentation Bomblets		Mainly Against Personnel and Crew

Figure B-2. Ordnance Weapon Selection Guide (Sheet 1 of 8)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
	EOGB's		
	General Purpose Bombs	Airburst	Mainly Against Personnel and Crew
	General Purpose Bombs	Instantaneous or Short Delay	
	Guided Weapons with Large LSC Warheads		
	LGB/GBU		
	20MM API		
b. In Revetments	Cluster Weapons with CSC Bomblets		Mainly Against Personnel and Crew
	EOGB's		
	General Purpose Bombs	Instantaneous & V.T.	(Low Alt Detonation)
	Guided Weapons with Large LSC Warheads		
	LGB/GBU		
c. In Covered Positions	General Purpose Bombs	Delay	
	Guided Weapons with Large Warheads		
4. Anti-Aircraft Artillery			
a. Automatic	Same as 3 with the Following Exceptions:		Against Light Honeycomb Radar Vans
	Firebombs		
	20MM HEI		Against Off-Carriage Fire Control
b. Self-Propelled	Same as 2		Some are Open on Top and are Susceptible to HEI Projectiles and Cluster Weapons W/Shaped-Charge Bomblets
5. Rocket Launchers	Cluster Weapons with CSC Bomblets		
	General Purpose Bombs	Instantaneous or V.T.	
	Guided Weapons with Large Warheads		

Figure B-2. Ordnance Weapon Selection Guide (Sheet 2 of 8)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
6. Missile Sites			
a. SAM (Surface-to-air Missiles)	Anti-Radiation Missiles Followed by Cluster Weapons with Frag or Shaped-Charge		To Temporarily Disable Radar *
	Bomblets or Retarded Bombs	Instantaneous	
	General Purpose Bombs	V.T. Instantaneous	(Delivered Inside of Revetment)
b. SSM (Surface-to-Surface Missiles)	Same as for Armored Vehicles with the Following Exceptions:		
— Against Liquid Fueled Missiles	Cluster Weapons Followed by Incendiary Munitions or Firebombs		
	General Purpose Bombs	Contact Fuzed	
	General Purpose Bombs	V.T.	(Low Altitude Burst)
— Against Solid Fueled Missiles	Cluster Weapons W/Shaped Charge Bomblets		
	EOGB's General Purpose Bombs LGB's	Contact	
7. Radar Installations	Anti-Radiation Missiles		(If Target is Radiating)
	Cluster Weapons with Fragmentation or Shaped-Charge Bomblets		
	EOGB's or LGB/GBU with Frag or Shaped Charge Bomblets		
	Fire bombs		Direct Hit or Near Miss on Light Honeycomb Radar Van
	General Purpose Bombs	V.T. & Instantaneous	
	20MM		Hit on Radar Van
	Tow		
	Hellfire		

Figure B-2. Ordnance Weapon Selection Guide (Sheet 3 of 8)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
8. Airfields			
a. Parked Aircraft			
— In open, Uncovered or in Lightly Covered Revetments	Cluster Weapons with Fragmentation or Small Shaped-Charge Bomblets		
	EOGB's or LGB/GBU with Frag or LSC Warheads		
	Firebombs		(Direct Hit on Each Aircraft Target) (Hit within Revetment)
	General Purpose Bombs	Instantaneous	
	Penetrating Weapons Followed by Incendiary Munitions		
	Small Fragmentation Weapons		
	Strafing Attacks with Guns or Rockets		
— In Heavily Covered Revetment	Guided Bombs or Missiles Capable of Penetrating Roof	Long Delay	(If Sufficient Target Signature)
b. Runways (And Large Roads)	General Purpose Bombs with Steel Nose Plugs	Short Delay Tail Fuze	
c. Hangars	EOGB's or LGB/GBU with Large Warheads	Short Delay	
	General Purpose Bombs	Short Delay	
d. Hardened Aircraft Shelters	Guided Weapons Against Shelter Door or Track		(If not Imbedded in Concrete)
	Large General Purpose Bombs	Long Delay	
9. Field Fortifications	General Purpose Bombs	Long Delay	
	Guided Weapons that Impact W/Explosive Weights of 190 Pounds or Larger (MK 82 or Larger)		

Figure B-2. Ordnance Weapon Selection Guide (Sheet 4 of 8)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
10. Supply Depots or Dumps			
a. Stacked Ammo	CSC and LSC Weapons Fire & Incendiary Weapons Large Blast and fragment Weapons		Direct Hit if Wood Crated
b. POL Storage Tanks	Large Blast and Fragmentation Weapons Large CSC or LSC Weapons		(Direct Hit) EOGB's Recommended
c. POL Storage Drums	General Purpose Bombs CSC or LSC Weapons Small Fragmenting Bomblets		(Direct Hit)
d. POL Underground Storage	General Purpose Bombs	Penetration and/or Cratering (Delay and/or SteeliNose Plug)	
11. Land Transportation			
a. Roads	Large General Purpose Bombs	Delay	Dropped Singly
	Smaller General Purpose Bombs	Delay	Salvo or Stick
b. Trucks	Cluster Weapons with Fragmenting or Shaped-Charges Firebombs		If Transporting Flammable or Explosive Cargo
	Fragmentation or Incendiary Bomblets General Purpose Bombs Guided Weapons Shaped Charge Weapons Strafing Attacks		

Figure B-2. Ordnance Weapon Selection Guide (Sheet 5 of 8)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
c. Railways			
— Track	General Purpose Bombs Landmines	(Cratering)	Unretarded
— Rolling Stock	General Purpose Bombs	Instantaneous and Short Delay	
	Guided Weapons with Large Warheads		
	Incendiary Weapons		If Cargo is Reactive or Car is Wooden
— Locomotives	Cluster Weapons with Shaped Charges		(If Strikes Vital Components)
	General Purpose Bombs	Instantaneous	
	Guided Weapons with Large Fragmentation LSC or CSC Warheads		
	Projectiles and Rockets		(Given a Hit)
d. Tunnels	H.E. General Purpose	Delay	Unretarded
e. Bridges			
— Permanent	Guided Weapons with Large HE or LSC Warheads	Instantaneous	
— Temporary Timber Deck	HE Weapons		
Cable	General Purpose Bombs with Steel Nose Plug	Delay	
Pontoon	CSC Weapons Weapons that Produce Fragments		
Bamboo	Weapons Delay Fuzed for Underwater Explosions		
12. Water Transporation			
a. Inland Canals	General Purpose Bombs Demolition Bombs Penetration Bombs	Delay Delay	

Figure B-2. Ordnance Weapon Selection Guide (Sheet 6 of 8)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
b. Locks	Air Delivered Torpedoes Floating Mines General Purpose Bombs Rockets	Delay & Instantaneous	
c. Port Facilities			
d. Merchant Ships	General Purpose Bombs Guided Missiles with Penetration Capability	Delay Delay	
e. Junks and Sampans	Weapons with 5 inches or Larger Warheads General Purpose Bombs	 Delay	(Given a Direct Hit)
f. Barges and Small Craft	General Purpose Bombs Guns and Rockets	Short Delay or Instantaneous	If Cargo is Reactive
g. Soviet Naval Vessels	Anti-Radiation Missiles Cluster Weapons with Shaped Charge Warheads E.O. Guided Missiles General Purpose Bombs LGB/GBU Torpedoes	V.T. and Delay	Delivered W/Accurate Bombing Systems
13. Buildings	General Purpose Bombs Guided Weapons with LSC or Large H.E. Warheads Incendiary Weapons	Short Delay	Only if Building Contents are Combustible
14. Powerplants	Same as for Building but no Incendiary Weapons		
15. Transformer Substations	Cluster Weapons General Purpose Bombs Guided Weapons with LSC and Fragmenting Warheads Rocket & Gun Strafing	Instantaneous	Fragments Over 30 Grains
a. Earthen	Largest Available General Purpose Bomb	Delay	

Figure B-2. Ordnance Weapon Selection Guide (Sheet 7 of 8)

TARGET	RECOMMENDED ORDNANCE	FUZING	COMMENTS
b. Concrete	Depth Bombs Large General Purpose Bombs	Hydrostatic Delay	
16. Industrial Targets	General Purpose Bombs	Short Delay Instantaneous	If Combustible Contents
	Guided Weapons with LSC or Large H.E. Warheads		
	Incendiaries		If Combustible Contents

Figure B-2. Ordnance Weapon Selection Guide (Sheet 8 of 8)

of the attack aircraft, the FAC(A) may have difficulty in maintaining positive visual contact at all times.

B.12.3 Cloverleaf Attack Pattern. The cloverleaf pattern is a modification of the wagonwheel, with the same general inherent advantages and disadvantages. In the cloverleaf pattern, the leader initiates the attack on the desired run-in, with his wingman in trail behind him. A 270° turn is initiated by the leader on pullup; the next run-in is initiated 90° from the preceding run, and so on, until the attack is complete. The wingman follows the leader with appropriate separation.

B.12.4 Pop-Up Attack. The pop-up attack has been devised to permit CAS in some medium- and high-threat areas. The attack aircraft penetrates from an initial point (IP) on a preplanned route to the target, flying at altitudes below the threat envelope. Upon reaching the pull-up point (PUP), the aircraft climbs steeply, acquires the target, and pulls down to a dive delivery. While the pop-up attack provides good accuracy with improved survivability, it requires much more planning than low-threat attack patterns and is less flexible. Acquisition and tracking time is also less, so the attack pilot must be given an accurate target description. If the lead aircraft of a flight is carrying fragmentation ordnance, an interval must be established for the wingman's attack.

B.12.5 Loft Attack. The loft attack is not normally considered a CAS attack pattern due to the relatively large CEPs associated with it. On the high-threat battlefield, however, its use may be considered, as improvements in aircraft systems and guided weapons permit greater accuracy. The aircraft penetrates at low altitude on a heading directly toward the target. At a preplanned point, he commences a programmed pullup, and the ordnance is automatically released in a nose-high attitude. Maximum standoff is achieved with a release at about 40° nose-high. The limited accuracy of the loft attack is partially offset by the unparalleled levels of surprise and survivability it provides.

B.12.6 All-Weather Attack. The four types of all-weather attack currently in use are air support radar team (ASRT) control, beacon offset, radar or radar offset, and airborne moving target indicator (AMTI) bombing. Any jet attack aircraft can drop ordnance under ASRT control. For conduct of ASRT missions, refer to FMFM 5-1, Chapter 6. All-weather deliveries provide the FAC(A) with a valuable option when faced with deteriorating weather conditions. In a high-threat environment, such deliveries would require extensive prior planning and, in most cases, EW support because of the relatively long exposure times of the aircraft to enemy air defense weapons. The FAC(A) may be called upon to observe and adjust any of these drops when weather conditions are too low for visual CAS.

B.12.7 Attack Helicopter Attacks. Attack helicopters will utilize the cloverleaf, wagonwheel, and racetrack patterns when the threat permits. When not operating in a permissive environment, they are forced to lower altitudes and will use either running or hover fire from the maximum range of their onboard weapons. After receiving their brief in the holding area (HA), they will proceed to the attack position (AP) which is a concealed position from which they will unmask and fire on their targets.

B.13 DAY AIRBORNE CONTROL TECHNIQUES

B.13.1 Premission Tasks. The five major premission tasks in airborne control involve target location, target analysis, communications, mission clearance, and priority. Location of the target, in coordinates accurate to 100 meters, is the first task. A tacan/DME fix of the target should be accurate to within 1 mile. The controller's position must be located so that intentions are not telegraphed by orbiting directly over the target. Location of rendezvous with attack aircraft requires tacan/DME radial and distance, or a prominent terrain feature. Visually spot all friendly unit locations within 1,000 meters of target. For the target analysis task, the type of target and its protection must be determined, including size, hardness, natural/manmade protections, and tactical influence. Weapon selection will involve the type and amount of ordnance required to achieve desired damage to target, plus fuzing considerations. Communications must be established with control agencies (DASC, TAOC or ASRT, and TACC), ground unit involved, and other aircraft influenced by the air strike (such as helicopters). Clearance to conduct the mission must originate with the local ground unit commander who will be affected by the air strike, or with the unit commander having authority over the area. Coordination with other supporting arms and associated units, such as reconnaissance teams or allied forces, must be assured. Mission priority should be assigned by the ground unit commander needing the support. If no ground unit is involved, the TAC(A) assigns the priority, and DASC will verify or reassign priorities as necessary.

B.13.2 Requesting Aircraft. The DASC is the primary source for requesting immediate air support aircraft. Utilize either the TAR net or the TAD net and check with the ground unit to see if they have already requested air.

B.13.2.1 Aircraft Sources

1. On-station or on-call aircraft. (See Figure B-1 for communications and ordnance capabilities.)

    (a) Prebriefed for specific purpose of mission

    (b) Pre-positioned in either an airborne or ground alert status for a conditional period of time awaiting mission assignment from the DASC.

2. Alert or hot-pad aircraft.

WEAPON	UNDER COVER (METERS)	STANDING (METERS)
MK 81 LDGP	200	750
SNAKEYE	100	700
MK 82 LDGP and LGB/GBU	200	850
SNAKEYE	110	800
VT Fuze	1500	1500
MK 83	225	900
MK 84	255	950
2.75 Inch FFAR	100	275
5.0 Inch ZUNI	200	600
MK 77	200	200
CBU-55/72	900	900
WALLEYE I	1000	1500
WALLEYE II	1500	2000
MK 20 ROCKEYE, CBU-59 APAM Maverick	400	400
20MM Cannon	25	175
7.62 and 50 Caliber Guns	25	25
TOW	25	50
HELLFIRE	25	50

Figure B-3. Recommended Minimum Safe Distances for Friendly Troops

(a) Available for emergency missions or priority missions and must be scrambled by the TACC/TADC or the DASC (if assigned launch authority).

3. Divert aircraft.

(a) Diverted for your control from missions of lesser priority

(b) Diverted for your control from other TAC(A)s

(c) Diverted for your control due to inclement weather in primary target areas.

B.13.2.2 Information That Must Be Provided to the DASC When Requesting Attack Air Includes:

1. Controller's call sign and location
2. Type of target and priority of mission
3. Supported ground unit
4. Location of target
5. Type and amount of ordnance desired and fuzing.

B.13.2.3 Information That the DASC Will Provide to the Controller

1. Call sign and line up of aircraft to be utilized on the mission
2. ETA of first flight of aircraft and ordnance loading
3. Assignment of a TAD mission frequency
4. Clearance to run the mission.

B.13.3 Attack Planning. Attack planning includes determining the target elevation, the best approach to the target, attack heading, pulloff direction, attack pattern (if multiple runs are feasible), and retirement route.

An accurate value for target elevation is important. To convert elevation data from meters to feet, multiply the elevation in meters by 3.28. For Snakeye bombs or napalm, take target vegetation and trees into consideration. Conditions permitting, plan the pulloff:

1. Away from hazardous terrain or enemy ground fire
2. Around the friendly unit
3. Away from bad weather
4. Toward the nearest safe area.

In a low-threat environment, multiple runs may be possible. If so, decide what attack pattern will produce best results and what ordnance will be delivered on each pass.

Note

If the ordnance load includes napalm, consideration should be given to dropping it first. This will allow higher attack airspeeds on subsequent passes and reduce the danger of enemy ground fire igniting the napalm on the aircraft. A disadvantage to this plan is the chance of subsequent bomb blasts smothering the napalm.

B.13.4 Coordination. The major coordination requirements for airborne controllers are keeping other agencies informed of the situation and the assignment of orbit points to other aircraft when needed. The ground unit needs to know how long it will be until strike aircraft arrive, which ordnance will be delivered, and at what position. Other aircraft in the area, such as transport helicopters and gunships, require coordination regarding suppressive fire, timing, and patterns. Control agencies which must be kept informed are DASC and FSCC. In addition, other supporting arms may require coordination if it will be necessary to check fire during artillery or naval gunfire. The need for establishment of restrictive fire plans and for artillery or naval gunfire should be determined in case they are needed to supplement the air strike. Coordination with other aircraft in the assignment of orbit points may be needed. Helicopters must remain clear at an orbit point which is safe from the enemy AAW threat. In low-threat areas, follow-on flights of fixed-wing aircraft should orbit overhead at higher altitudes to observe, while avoiding interference. Position of the orbit point should be identified by tacan radial and DME distance, or by large, prominent terrain features. If necessary, 1,000-foot separation altitude assignments should be made for multiple flights. To avoid interference with other supporting arms, orbit points should be established clear of gun-target lines and above the maximum ordnance associated with either artillery or naval gunfire.

B.13.5 Rendezvous With Strike Aircraft. Initial communications with strike aircraft will be on the TAD net or in accordance with DASC instructions. As quickly as possible, the TAC(A) or FAC(A) should obtain the following information from the strike aircraft: number of aircraft, type and call sign, number and type of ordnance carried, target area ETA, and fuel time on station (minutes). The following information must be passed to the strike aircraft by the TAC(A) or FAC(A): TAC(A) position (tacan radial/DME), TAC(A) aircraft type and altitude, artillery/naval gunfire, airspace coordination area information, and traffic advisories on other aircraft in the area. At the TAC(A)'s discretion, the briefing can be initiated as soon as the flight checks in, unless there are problems in marrying up with the fixed-wing aircraft.

Other methods include UHF homing with tacan air-to-air ranging, description of large or prominent terrain features, rendezvous over a point known to both TAC(A) and strike aircraft before proceeding to target, and use of TAOC or ASRT radar. Other information required from the TAC(A) by strike aircraft includes: orbit points (if necessary), general situation brief, expected delay on attacking the target, and weather in the target area.

B.13.6 Target Briefing. The briefing for strike aircraft should always proceed from general information to specific data. (See Figures B-4 and B-5.) Whenever possible, a brief situation report should be included. The tunnel method of briefing should also be used for terrain description, proceeding from general to more specific features of target designation. Strike aircraft may receive the target brief from any controller/controlling agency. Earliest reception of the target brief will allow for more detailed planning at greater distances from the target area.

B.13.7 Methods of Marking Targets. The normal method of target marking is utilization of 2.75-inch FFAR white phosphorous rockets. As an alternate method, 2.75-inch FFAR high-explosive rockets can be used to mark the target; however, the smoke dissipates rapidly. Some type of ground reference should be available for strike aircraft visual relationship to use in bombing. Request the friendly units to mark their position simultaneously with your mark for additional aid in target acquisition by the strike aircraft.

Note

> The friendly units markings should utilize a color and/or method other than that used for target marking.

Other marking methods include the use of smoke grenades, white phosphorous (mortar/tank/artillery/naval gunfire) shells, ground organic weapons, and target overflight.

CAUTION

> Exercise care in the use of hand-held smoke. Do not call for a specific color, since the enemy could have the same smoke capability.

Mortar, tank, artillery, or naval gunfire white phosphorous may be the safest to use in highly defended target areas, but detailed advance coordination with the units involved is required. If the ground units can see the target and can reach it, a more accurate mark is

Msn # ____________________ Ord ____________________

Route ____________________

En Route Freq ____________________

Msn Codes: Continue __________ Change __________

Cancel __________ Abort __________

Contact Point:

CP __________ /Controller Call Sign __________ /Freq __________

1. IP ____________________
2. Hdng __________ °Mag __________ Offset: L __________ R __________
3. Distance ____________________
4. Tgt Elev ____________________
5. Tgt Desc ____________________
6. Tgt Location ____________________
7. Mark Type __________ Code __________
8. Friendlies ____________________
9. Egress ____________________
10. BCN-Tgt __________ BRNG/BCN Grid __________
11. BCN-Tgt __________ Meters/Tgt Grid __________
12. BCN Elevation __________ Feet __________

Remarks

TOT/TTT ____________________ (min) "HACK"

Figure B-4. CAS Target Briefing Form

Msn # Mission Number. The mission number is assigned to a flight by the TACC. The mission number will be used as the flights call sign.

Ordnance Code. The ordnance code denotes what weapons and fuzing are carried in the flight.

Route. The route is the routing assigned to the flight for the entire mission. The route will be given in coded control points.

Enroute Freq. Extra space to list Enroute frequencies.

Msn Codes. One of four codes could be given during the mission. Continue (Cont) – for continue the mission as planned; Change (Chg) – indicates there is a change to the basic mission; Cancel (Cnx) – indicates the need for this mission no longer exists; Abort – this code is the single word used by the FAC or FAC(A) to stop ordnance release from the aircraft in the attack.

CP CALL on – Indicates the terminal controller call sign and coded frequency to be used by ingressing CAS aircrews.

1. I.P. – Initial Point. For attack helicopters attack position (AP).

2. Hdg – Heading. The heading is given in degrees magnetic. It is the heading from the I.P. to the target. L/R indicates offset direction if restriction exists. The offset direction indicates the side of the IP to target line on which the attack aircraft is cleared to maneuver/position himself to attack. For attack helicopters, this is the heading from the center of the attack position to the target.

3. Dist – Distance. The distance is from the I.P. to a point on the target. The distance is always given in nautical miles (NM), down to tenths. For example, 12.3 NM would be spoken as, "Twelve point three." For the attack helicopters, this is the distance from the center of the attack position to the target expressed in meters.

4. Tgt Elev – Target Elevation. The target elevation is always in feet above mean sea level (ft. MSL).

5. Tgt Desc – Target Description. The target description is brief and general. Its function is to help the pilot anticipate visual cues for target acquisition.

6. **Tgt Location – Target Location. The target location will be either UTM grid coordinates or latitude and longtitude.**

7. Mark. The type of mark will be given be it smoke, photo flash, or laser. If a code is to be incorporated it will be given.

8. Friendlies. The friendly position will be given in cardinal headings from target. (North, South, East, West). The distance of friendlies from the target will be given in meters.

9. Egress. Instructions will indicate the cardinal direction in which aircraft are recommended to egress the target and control points to follow to exit the terminal control arena. The word "Egress" will be transmitted when giving egress instructions.

10. **BCN-Tgt – Beacon Target. From beacon to target bearing will be given in degrees magnetic. (For Hellfire, mule to target bearing).**

11. **BCN-Tgt – Beacon Target. Beacon to target distance will be given in meters. (For Hellfire, mule to target distance (meters)).**

Figure B-5. Definition of Terms (Sheet 1 of 2)

12. BCN-Elev – Beacon Elevation. The Beacon Elevation will be given in feet MSL. (For Hellfire, mule elevation).

Time to Target (TTT). Number of minutes and seconds to ordnance on target. When communication is available, this ensures the necessary coordination between the FAC and the strike aircraft. This time is given by the terminal controller to properly coordinate with other supporting arms/ground elements, and be in position to mark the target. The time is followed by the word ("HACK" to ensure time synchronization between the terminal controller and the strike aircraft. If the time cannot be met by the flight leader, the leader must respond with the earliest time capable of ordnance delivery. The terminal controller must then accept or give a longer time to facilitate the attack pilots delivery of ordnance on target. The terminal controller is responsible to have the Mark on the target 20 to 30 seconds prior to the bombs on target. For example: The FAC has given the target brief and concluded with eight plus zero zero, "HACK." The flight leader says, "Line two." The FAC will answer with "270 degrees." If the flight leader has no discrepancies in the brief and the 8-minute time Hack is acceptable, he says, "Eight plus zero, zero." However, if the time is too short, the flight leader will say, "Negative, 11 plus zero, zero." The FAC then reexamines the situation and says, "Eleven plus zero, zero." The flight leader should say, "Eleven plus zero, zero," This informs the FAC that the attacking aircrew has a good copy on the brief, the hacking of the clock was accomplished, and that 11 minutes is sufficient time to deliver ordnance on the target.

The term "Time on Target (TOT)" is the specified time used for preplanned targets (i.e., 1535 local time). The TOT should be placed in the same slot as the TTT; however, remember there is no time "HACK" for TOT.

Remarks: (If Applicable)

A. Threat

B. Hazards

C. Weather

D. Ord Delivery

E. "Restricted Final Attack Heading"

Figure B-5. Definition of Terms (Sheet 2 of 2)

provided by ground organic weapons. Overflight of the target is the least desirable method because it is inaccurate and is hazardous to the TAC(A) or FAC(A). Marking by target overflight usually necessitates a low-level, dummy pass by the strike aircraft.

B.13.8 Calls and Clearances. Calls required by strike aircraft are published in range SOPs or operations orders. Training operators may require the most restrictive of environments for safety. In this environment calls required by strike aircraft during the attack are "ROLLING IN" and "OFF TARGET." If the terminal controller encounters difficulty in acquiring the strike aircraft, he should request a call of "ABEAM" or "180° POSITION," in addition to the rolling in call. Standard terminology in accordance with ACP 165 (Operational Brevity Codes) should be used by the TAC(A) in communicating with attack aircraft.

Figure B-5 provides a listing of defined terms. Additional terms of primary importance include the following:

TERM	MEANING
Cleared to roll in	I acknowledge your visual acquisition of the target. You are cleared to initiate the run.
Continue	You appear to be tracking on the correct target and are cleared to continue the run.

CAUTION

"CONTINUE" is not a clearance to release ordnance.

TERM	MEANING
Cleared hot	You are cleared to release the requested ordnance at your discretion.
Abort, Abort, Abort	Abort run immediately; do not release ordnance. Return ordnance switches to SAFE.
Go high and dry	Establish an orbit pattern with ordnance switches SAFE, and await further clearance.

B.14 CONTROL OF THE ATTACK

B.14.1 Low Threat

B.14.1.1 Controller's Position. There is no requirement that the FAC(A) must be in a certain position during the strike, or must fly a certain pattern. The primary considerations for the controller's position are as follows:

1. Maintain a position for observation of the target, the supported ground unit, and the strike aircraft (at the time he is in drop position) to assure maximum safety of friendly personnel when clearance is given.

2. Attempt to keep in position to roll-in for an ordnance pass when necessary, either for remarking the target or for suppressive fire.

3. Hold a position which will not interfere with the strike aircraft.

Patterns which can be flown for optimum FAC(A) position include the inside racetrack, outside orbit, and figure eight. The inside racetrack is maintained over the friendly unit, but inside the attack aircraft, and provides the best protection for the friendly unit. The outside orbit may provide better observation of the target; however, greater exposure to ground fire is also possible. The figure eight pattern can be flown inside, outside, or crossing between the two options. This provides continuous observation of target, friendly unit, and strike aircraft, and keeps the FAC(A) in position for target remark or fire suppression. Altitude should be maintained out of range of small arms fire (1,500 feet), and airspeed should be as high as possible, consistent with good observation requirements, and within aircraft performance capability. Be aware of (and avoid) frag patterns from strike ordnance.

B.14.1.2 Adjusting Impacts. Although any method which involves a direction and a distance from a ground reference may be used to adjust ordnance impacts, the preferred method for FAC(A) corrections is the use of a clock code and distance in meters from the last weapon's impact. When giving corrections, consider the normal CEP of the particular weapon and its area of effectiveness. It may not be necessary to achieve a direct hit on a target to destroy or neutralize it. Other considerations for adjusting impacts are target neutralization versus destruction, area coverage versus point destruction, and immediate suppressive fire for helicopter support versus target destruction with delayed results.

B.14.2 Medium Threat. If weather permits the FAC(A) to operate above the threat envelope, CAS control procedures are much the same as in a low-threat area. The higher altitudes make the 5-inch Zuni more suitable for marking, but with practice the 2.75-inch rocket can also be used.

The best approach to the target is especially important in medium- and high-threat areas where the penetration will be made at low altitude. For a pop-up attack, the magnetic heading and time to pull up from the IP must be computed. Clear plastic templates can be locally reproduced to permit the FAC(A) to determine this information quickly. For loft attacks, the attack pilot will require the magnetic heading and distance (feet) from the IP to the target. He then computes his own pullup point based on ordnance data figured during his preflight planning.

Whenever possible, select run-in headings parallel to friendly unit lines.

Note

> The minimum safe distances for troops in Figure B-3 are based on parallel run-ins.

Consider terrain features and enemy defenses which may present a hazard to strike aircraft. Avoiding crosswind run-ins will make corrections easier and avoid target obscuration. If the run-in can be made out of the sun, better visibility for strike aircraft is afforded, while enemy gunner tracking and firing is more difficult. An allowance of 10° to 20° is necessary on either side of the run-in heading for jinking. If the terrain is mountainous, consideration must be given to the fact that a pass which travels uphill is more accurate for weapon delivery, but may offer a terrain clearance hazard to the delivery aircraft. Often, a compromise selection which results in a run-in heading across the slope is desirable. Keep alert for enemy fighter aircraft which may use the plume of the marking rocket to locate both the attack aircraft and the FAC(A).

If weather and/or the tactical situation does not permit the high altitudes required to remain above the threat, use the high-threat tactics described in the following paragraphs.

B.14.3 High Threat. Utilize supporting arms to mark the target, if possible. If not, plan a pop-up mark or a lofted mark, timed to impact a few seconds prior to the attack aircraft's pull up. A ground FAC, if available, should provide the correction from the mark.

B.14.4 Follow-On Flights. If further air support is needed on the target, lead time should be planned so that no breaks occur in flights on target. Also, consider FAC(A) time on station, since it may be necessary to obtain controller relief. Allow as much lead time as possible when requesting a change in ordnance loading, and consider the effect of weather. Assign an orbit point to follow-on flights if more than one flight is expected in the area at a time. Altitude separation of at least 1,000 feet between orbiting flights must be assured. Normally, the flight having the desired ordnance on board should be used first. If all flights have the same ordnance, they should be used in order of least time on station. If follow-on flights have been on the frequency and have been observing preceding strikes, the briefing may not require as much detail as did the initial flights. Any changes from the previous brief should be given as deviation. A thorough briefing for the FAC(A)'s or TAC(A)'s relief on station includes (but is not limited to) friendly situation, enemy situation, supporting arms, and recommendations.

B.14.5 Special Considerations. Changing weather may dictate changes in ordnance requirements and delivery tactics. Do not depend on holes in the overcast. When controlling other aircraft, assign holding points, or orbit areas which prevent their interference with the conduct of the strike, but keep them immediately abreast of the situation. The TAD frequency used by the FAC(A) is a discrete frequency; all nonessential communications should be accomplished on either FM or another UHF. If the air strike is to be utilized as suppressive fire for the transport helicopters, thorough coordination with them is required. When the FAC(A) has a wingman assigned, confusion as to which is the FAC(A) can be eliminated by holding the wingman out of the area, or by verifying the lead aircraft (landing light on, wing rocking, identification turn). For extremely close drops (inside 200 meters) mark the first drop farther away from the friendly unit, moving gradually into the target. Assure that all parties involved understand how critical and tight the situation is. The friendly units must mark their positions very well and must protect themselves as much as possible. The controller should have positive, two-way UHF communications with the strike aircraft and positive, two-way communications with the supported infantry unit. However, receiver-only attack aircraft may be used as the situation dictates.

B.15 NIGHT CAS CONTROL

Night CAS imposes even greater responsibilities on the FAC(A) than day CAS. Target marking and aircraft acquisition are more difficult. Normally, illumination of the target and hazardous terrain must be provided. Even in clear weather with illumination, pilots must deal with the problems of vertigo, target fixation, inadequate terrain discrimination, and increased potential for midair collision. Accomplish as much planning and coordination as possible prior to the arrival of the attack aircraft on station. Friendly units should be prepared to mark their positions and, if possible, the target. If illumination is required, adjust it well in advance. Clearance to conduct the mission can be a significant problem if the target is close to friendlies. A good understanding of the desires of the ground unit commander, proper preparation, and professional voice procedures will help ensure there is no delay in obtaining clearance.

Use radio navigational aids, radar vectors, and aircraft lighting to rendezvous with other mission aircraft. The target briefing should cover thoroughly the method of marking the target and friendlies, location of hazardous terrain, and other aircraft in the area. If possible, establish positive aircraft separation by altitude or by airspace assignments. This will permit lights-out operation to the maximum extent possible when required by the threat.

Utilization of the ASRT as a terminal controller negates the requirement for target marking/illumination.

Commence illumination a few minutes prior to the strike to permit any final adjustments. Flares are normally positioned up to the 12 o'clock position on the target run-in line, and at the 6 o'clock position at 500 to 1,000 meters, unless the strike aircraft desire other positions. Flares should not drift across the run-in line above the minimum pull-out altitude of the attack aircraft. After initiating illumination, it should be maintained at a constant level until the mission is completed. Initial flares should be used to determine wind within the target area.

B.15.1 Low-Threat Tactics. In a low-threat environment, aircraft paraflares provide best illumination. Although several types of aircraft can be used as flareships, normally a cargo-type (C-130) aircraft with a long endurance capability and large flare capacity will be used. Strike aircraft may be employed, either with one aircraft in the flight of two acting as the flareship or with a split ordnance/flare load on each aircraft. An OV-10A with flare capability can also serve as the flareship. Normal time on station for the cargo-type flareship is from 3 to 5 hours, including illumination time. Cruise airspeed while on station for a cargo type aircraft is 150 knots TAS. Normal illumination consists of strings 4, 6, or 10 flares. Maximum illumination would be strings of 10 to 12 flares. A string is defined as the number of flares expended along the drop line. Once a new initial flare point is reached (made by reversing course or proceeding back to the first point), another string can be released. The flare aircraft usually operates between 4,000 and 8,000 feet AGL. The minimum altitude at any time (depending on the type of flare expended) is 2,750 feet AGL. The maximum altitude is 13,500 feet

AGL. All flares are set to ignite at 2,500 feet AGL and illuminate until reaching the ground. Depending on the type of flare utilized, a burn time is between 3.5 to 5 minutes with a candle power between 1,600,000 to 2,000,000. After establishing the pattern, the flare aircraft will maintain a holding pattern. This can be done using TACAN, VOR: INS, OMEGA, radar (self-contained or CGI) or terrain reference (best with NVG utilization). The following patterns are standard and should be modified to support the mission:

1. Figure Eight — this is the best pattern for illumination of one specific point on the ground.

2. Ninety-Two-Seventy Turns — best when a long, narrow area needs coverage and a string is expended. A 90/270 at each end of the pattern quickly returns the aircraft to the reciprocal run-in heading over the same drop line.

3. Race Track — best for constant illumination of a large area.

4. Continuous Orbit — utilized to illuminate a small area and is particularly suited for MEDEVAC or extraction missions.

The flare pattern is offset to account for wind correction and is positioned upwind for flare drift. For racetrack or 90/270 patterns, the drop line is parallel to the run-in line. Turns after a specific string should be planned to be opposite to that of strike aircraft.

WARNING

Unlit or burned-out suspended flares are a hazard to flight.

Note

Flares dropped with less than a 13-second or half-mile interval are wasted. To ensure positive illumination however, two may be expended at each *mark*. In this case, a maximum string of six is available. A reload time of 5 minutes can be anticipated for another maximum string of six.

Target designation considerations at night are generally the same as during daylight, except that more frequent remarking of the target is necessary.

Unless otherwise desired or specified, the same patterns and considerations for attack aircraft and FAC(A) as in daylight operations apply. If no ground fire is encountered, it is preferred to have all aircraft lights on, if possible. Both the flare aircraft and the FAC(A) normally will have all of their lights on after rendezvous. Attack aircraft should turn on their lights as they call "ROLLING IN" and keep them on until they are "CLEARED HOT" by the FAC(A).

B.15.2 Medium-Threat Tactics. Night CAS in a medium-threat environment uses the same techniques as in a low threat, except at higher altitudes. The flareship must have set appropriate fuze times to permit the flares to illuminate at the proper altitude. Because of the increased difficulty the FAC(A) has in acquiring the target, coordinate with the ground FAC to provide marking. High-threat tactics may also be used.

B.15.3 High-Threat Tactics. In a high-threat environment, plan to use mortars, artillery, or naval gunfire for illumination. Ensure that the canister impact area is clear of friendly personnel and that sufficient light is available; tube-delivered flares burn for a relatively short duration.

The pop-up target brief must include a description of terrain along the ingress and egress routes. Have the ground FAC mark the target or provide a correction from an artillery mark.

B.16 HIGH-THREAT COMMUNICATION JAMMING ENVIRONMENT

This environment presents two separate problems which must be overcome. The first problem is the ability to receive or transmit required target information, and the second is the ability to arrive or direct attack aircraft to the appropriate pop point so that ordnance can be effectively delivered.

B.16.1 Essential Information

Standardization of target briefings as described in paragraph B.13.6 may not be possible in a high-threat environment. Different attack aircraft capabilities, tactics, and ordnance which may not be transmitted due to communication jamming may dictate burst transmitting essential items of information only:

1. Predesigned IP (in code)
2. Heading to target
3. Distance to target
4. Type target/target elevation.

With only these four bits of information, the mission can be accomplished. By giving this type of information (distance to target as opposed to time to pop point) in a communication jamming environment, the FAC is not dictating tactics to the attack aircraft.

The essential information is: How does the attack aircraft get to the appropriate pop point? This information is also needed to correctly brief pop-up deliveries as in Figure B-4.

B.16.2 Initial Point-to-Pop Point Derivation

Computing parameters for various IP-to-target distances yields a specific angular displacement from the given IP-to-target heading, as well as a specific distance to the pop point from the IP. Figure B-6 details the angular difference for IP-to-target for distances. Figure B-7 details the relationship of distances from IP-to-target to IP-to-pop point. Figures B-6 and B-7 provide the information for Figure B-8, which should be the basis for all pop-up attacks.

B.16.3 Application of IP-to-Pop Point

The FAC or FAC(A) has a target 15 miles from an IP on a heading of 360° from IP to target. The pilot has three basic options using Figure B-9.

1. Use dead reckoning, fly 351° for 1:17 at 540 knots and pop. Target is 60° right.
2. With the IP as the tacan station, fly out the 351° radial and pop at 11.5 miles.
3. Alter course as necessary to terrain mask or avoid threats; fly a mini point-to-point to the pop point.

The ability of the attacker to apply option 2 or 3 is dependent on attack aircraft instrumentation. This tactical procedure applies flexibility for the attacker to press the attack, and capability to enable the FAC or FAC(A) to provide positive guidance in communication jamming situations.

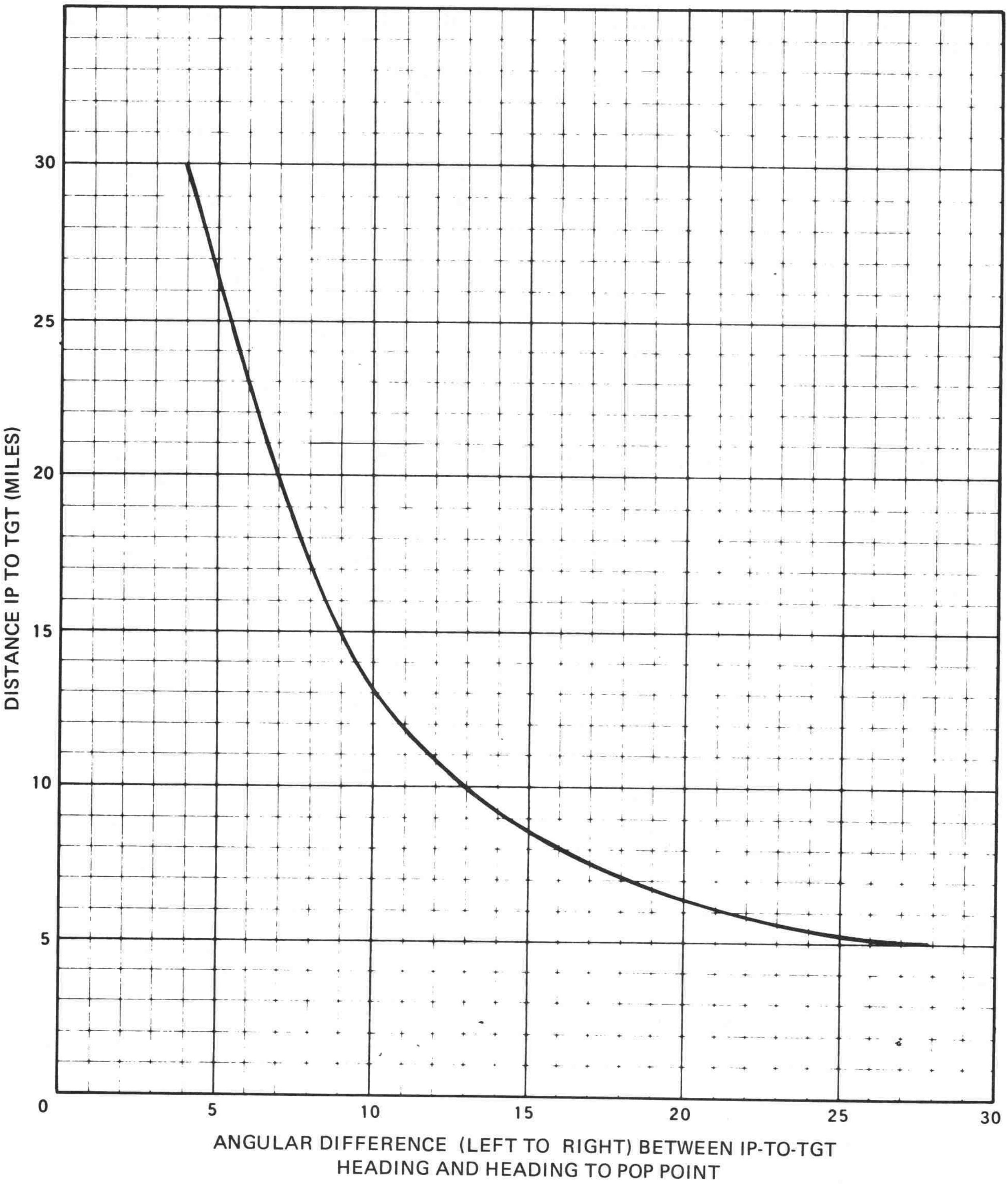


Figure B-6. Angular Displacement Chart

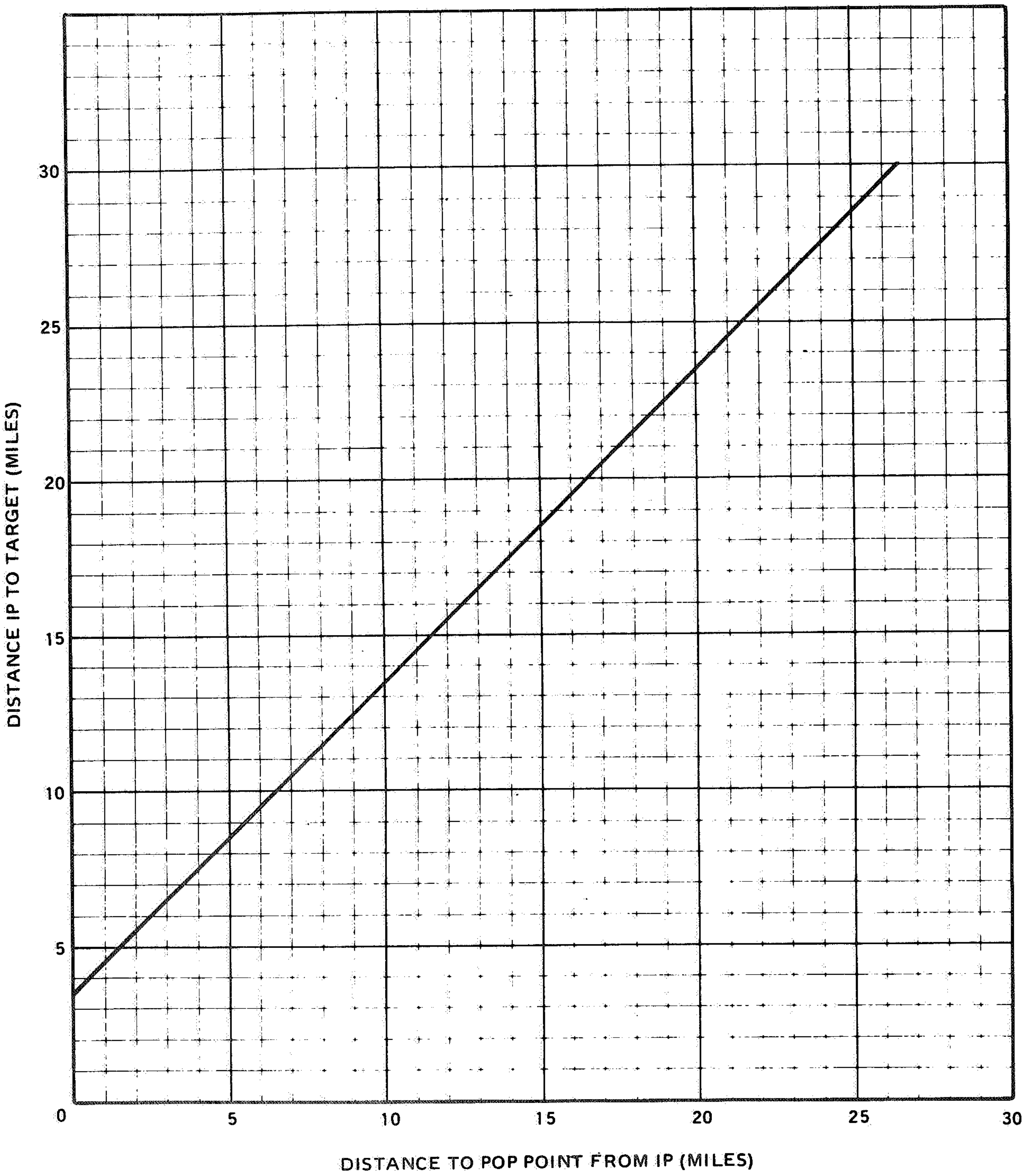


Figure B-7. Distance to Pop Point

IP-TGT NM	POP Hdg*	540 Time to POP	500 Time to POP	480 Time to POP	Distance to POP
30	4	2+56	3+11	3+19	26.5
29	4	2+50	3+04	3+11	25.5
28	5	2+43	2+56	3+04	24.5
27	5	2+36	2+49	2+56	23.5
26	5	2+30	2+42	2+49	22.5
25	6	2+23	2+35	2+41	21.5
24	6	2+16	2+28	2+34	20.5
23	6	2+10	2+20	2+25	19.5
22	7	2+03	2+13	2+19	18.5
21	7	1+57	2+06	2+11	17.5
20	7	1+50	1+59	2+04	16.5
19	7	1+43	1+52	1+56	15.5
18	8	1+36	1+43	1+48	14.5
17	8	1+29	1+36	1+40	13.5
16	8	1+23	1+30	1+34	12.5
15	9	1+17	1+23	1+26	11.5
14	9	1+10	1+16	1+19	10.5
13	10	1+03	1+08	1+11	9.5
12	11	+57	1+01	1+04	8.5
11	12	+51	+55	+57	7.5
10	13	+44	+48	+50	6.5
9	14	+37	+40	+41	5.5
8	16	+30	+32	+34	4.5
7	19	+23	+25	+26	3.5
6	22	+17	+18	+19	2.5
5	27	+10	+11	+11	1.5

*Degreesleft or right of IP-to-target heading to arrive at pop point.

Figure B-8. Pop-Up Delivery Computation Card

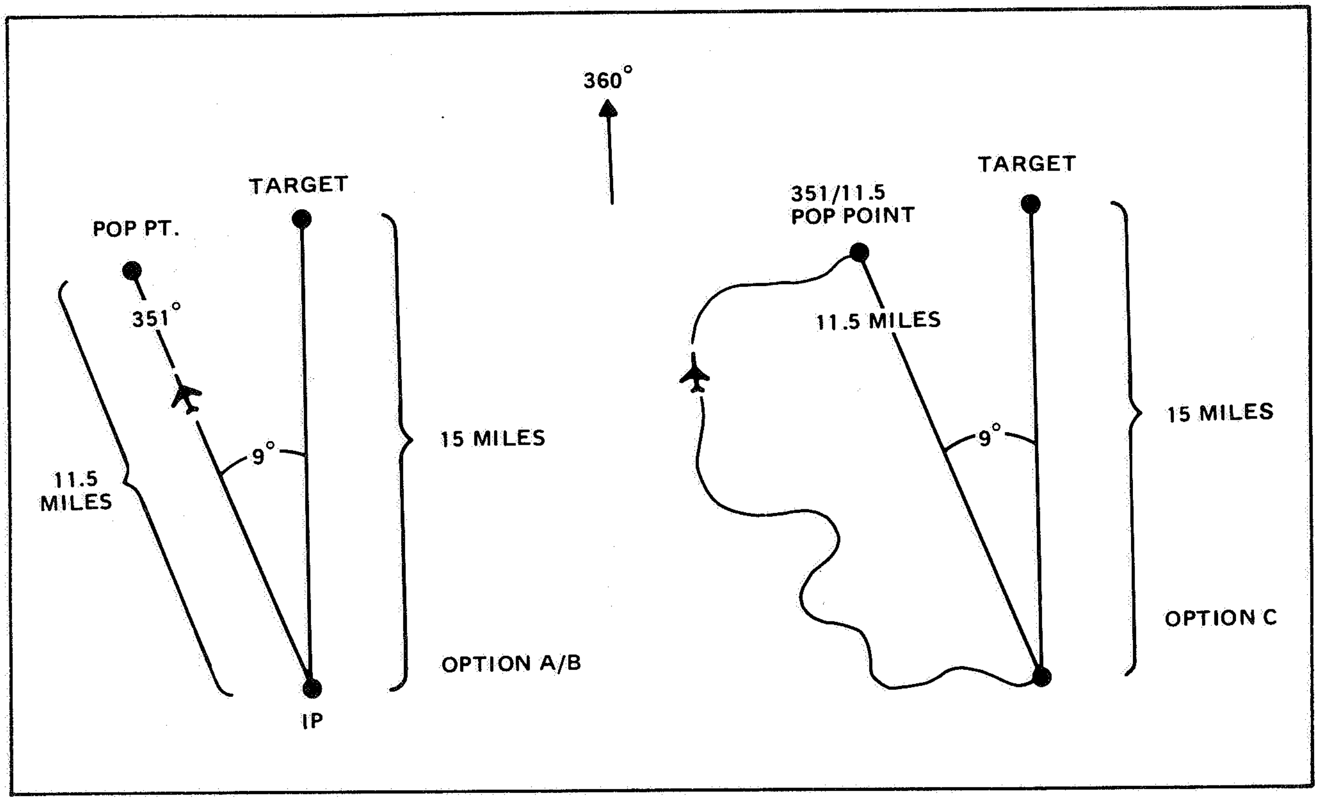


Figure B-9. Application of IP to Pop Point

APPENDIX C

Artillery/Naval Gunfire Adjustment

C.1 ARTILLERY SUPPORT

The assault support aircrew, within their mission capabilities, must be as familiar with artillery control as they are with air strike control. The crew must be familiar with the capabilities and characteristics of artillery weapons and ammunition and the considerations for their employment. Throughout history, artillery has provided the preponderance of fire support on the battlefield.

Artillery is capable of providing close and continuous fire support, and its fires can be massed rapidly on critical points. Prior to the artillery being landed, the task of providing the fire support for the landing force rests with air and naval gunfire. Artillery, through its organizational structure and unique capability to provide timely, close, accurate, and continuous fire support, is better suited to the particular requirements of the ground forces than other supporting arms. The capabilities of the field artillery system are as follows:

1. Rapidity of action - artillery possesses rapidity of action through its capability to quickly deliver conventional fires and nuclear fires on targets over a wide front without displacement.

2. Massing capability - artillery is capable of massing the fires of many weapons on one target or a series of targets to support the operations of ground forces. Successive volleys from one battery give the enemy time to react and seek protection, but massing the fires of several artillery batteries simultaneously will provide devastating results before the enemy can effectively react.

3. Fire without exposure - artillery is capable of sustained action in combat, since it delivers fire under all conditions of visibility, weather, and terrain.

4. Continuous support - artillery can deliver continuous support to maneuver units provided that artillery units make judicious displacements. Artillery unit movements must be carefully coordinated with the ground scheme of maneuver.

5. Variable trajectory - artillery variable trajectories enable attacking targets in defilade or fire from positions in defilade.

6. Surprise and shock - artillery can deliver fires without adjustment in order to increase the effects of shock and surprise. When it comes to casualty-producing effects, surprise fires are significantly more effective than adjusted fires.

7. Mobility - artillery possesses the ability to displace rapidly to new positions. Artillery must be as mobile as the force it supports.

8. Target acquisition - forward and aerial observers play an important role in the target acquisition mission of the field artillery. Artillery/mortar locating radars also play a key role in locating high priority targets.

9. Variety of ammunition - one of the greatest capabilities of the field artillery is its flexibility in providing a large variety of conventional and nuclear munitions.

Limitations of the field artillery system include the following:

1. Initial support - the principal limitation of field artillery with a landing force is the inability to support the initial phase of the amphibious assault.

2. Displacement - artillery units supporting operations ashore have reduced effectiveness during displacements and are particularly vulnerable to air attack.

3. Weight - the weight of artillery weapons and their ammunition limits employment in support of the helicopter operation. The surface mobility is sensitive to the characteristics of the area of operations resulting in reduced capability to support the operation.

4. Space requirement - the requirement for position areas ashore for artillery and the vulnerability to direct fire weapons restrict the time of landing and entry into combat in both the waterborne and helicopterborne assault.

5. Logistic support - the logistic support problem may be difficult in air movement, helicopterborne, and amphibious operations due to the weight and volume of artillery ammunition requirements.

6. Firing signature - because of its large firing signature, artillery is especially vulnerable to enemy target acquisition and counterbattery fires. Artillery units, especially nuclear-capable artillery units, are highly lucrative targets and receive high priority for attack.

7. Close combat - when required to defend themselves and their weapons against ground attack, an artillery unit may be required to engage an enemy in close combat. In such cases, artillery support is significantly reduced until the attack is repelled.

C.1.1 Standard Tactical Missions of Artillery. A tactical mission is a set of fire support responsibilities assigned an artillery unit. These missions are normally assigned by artillery regimental headquarters on order from the Marine division. Tactical missions are not usually assigned to artillery units smaller than a battalion. The aircrew should be familiar with who controls fires of artillery units depending on their tactical mission.

C.1.1.1 Direct Support (DS) Artillery. An artillery battalion is normally tasked with direct support of an infantry regiment. The direct support battalion provides observers to the supported unit companies and liaison officers to its battalions. When working in support of ground units, the aircrew should have a working knowledge of procedures for contacting that unit's direct support artillery. The direct support battalion answers calls for fire in priority from the supported units, its own observers, and higher artillery headquarters.

C.1.1.2 Reinforcing. An artillery unit, normally a battalion, can be tasked to reinforce another unit, usually a direct support battalion. A reinforcing unit answers calls for fire in priority from the reinforced unit, its own observers, and higher artillery headquarters.

C.1.1.3 General Support Artillery. An artillery unit, normally a battalion, can be tasked with general support of the force as a whole, usually the division or MAF. Its fires are controlled by higher artillery headquarters. Since a general support unit will seldom have observers organic to it, it is best employed in engagements of planned targets.

C.1.1.4 General Support - Reinforcing. This mission provides immediate responsive fires for the maneuver force as a whole, while at the same time augmenting the fires of another artillery unit when available.

C.1.2 Artillery Characteristics. To provide effective artillery support to the ground commander, the aircrew must have a thorough understanding of the capabilities of artillery weapons and ammunition. Artillery and mortar characteristics are depicted in Figure C-1.

C.1.2.1 81-mm Mortar, M129. Although technically classified as a mortar, the 81-mm mortar has long been known to Marine infantrymen as the battalion commander's "personal artillery." An 81-mm mortar platoon is located in the weapons company of each infantry battalion and is responsive to the battalion commander. This smooth bore, muzzle-loaded weapon weighs approximately 116 pounds complete and can fire a 9.5-pound projectile to a maximum range of 4,500 meters. In addition to the standard high explosive (HE) projectile, white phosphorous (WP) and illumination (ILLUM) projectiles are available.

C.1.2.2 105-mm Towed Howitzer M101A1. This 105-mm howitzer has been the backbone of Marine artillery since World War II. It is lightweight - about 4,980 pounds - versatile, and reliable. The M101A1 fires a 33-pound projectile about 11,000 meters and has a maximum rate of fire of 10 rounds per minute. The 105-mm fires HE, WP, ILLUM, smoke, antipersonnel (beehive), improved conventional munitions (ICM), gas (chemical) projectiles, and rocket-assisted projectiles (RAP).

C.1.2.3 155-mm Towed Howitzer M114A2. The M114A2 has many of the same traits as the M101A1. It, too, is World War II vintage and has been in the Marine inventory for three decades. This 155-mm towed howitzer weighs about 12,700 pounds and is towed by the M800 or M900 series 5-ton truck. Its arsenal of ammunition includes many of the same type of projectiles as the 105-mm howitzer but is expanded to include a greater variety of chemical munitions and a nuclear projectile. The M114A2 can fire its 95-pound conventional projectiles 14,600 meters or a RAP round as far as 19,700 meters.

C.1.2.4 155-mm Towed Howitzer M198. The M198 has finished advanced testing and is replacing the M101A1 (105-mm) as the Marine Corps' direct support artillery weapon. There are plans to also equip G.S. battalions with the M198 in the future. The M198 features improved reliability and maintainability over the standard towed howitzers. In addition to being able to fire all 155-mm ammunition in present stockpiles, the M198 is specifically designed to be used with new projectiles and propelling charges currently under development. When firing the new family of ammunition, the M198 has a range of 22,000 meters with the standard projectile and 30,000 with the RAP. The increase in range is not achieved without a compromise in size over previous howitzer systems. The M198 is significantly larger (over 40 feet long in the towed position and weighing 15,600 pounds) and requires a different prime mover (M813 5-ton truck or LVTP-7) than the M114A2. The M198 is easily transported by the CH-53E.

C.1.2.5 155-mm Self-Propelled Howitzer M109A1. The M109A1 (SP) howitzer is a highly mobile and responsive artillery system. It is widely used throughout the Army and by foreign countries such as Israel as the standard 155-mm howitzer system for a heavy division. It fires a wide variety of ammunition and has a range of 18,000 meters with the standard projectile and 24,500 meters with RAP. This SP howitzer has an enclosed turret that offers some degree of protection for the crew and weighs over 54,000 pounds.

C.1.2.6 8-Inch Self-Propelled (SP) Howitzer M110A2/3. The 8-inch system has long been heralded as the most accurate artillery weapon in the world. With its 200-pound projectile and pinpoint accuracy it can deliver a devastating blow to enemy positions well beyond the FEBA. Even though it weighs about 62,100 pounds, the 8-inch system is highly mobile on its self-propelled chassis. There is a good variety of ammunition available for the 8-inch howitzer including chemical and nuclear projectiles. It fires standard ammunition 22,900 meters RAP rounds to 30,000 meters.

Weapons	RANGE (M) See Note 1:	Approximate Operating Weight (Lb)	Reasonable Emplacement Time (MIN)	Rate of Fire RDS/Min		Prime Mover	Ammunition See Notes 2 & 3		Weight of Standard HE Projectile (Lbs)	Burst Area (M)
				First 3 Min	Sustained		Projectile	Fuze		
105mm Howitzer Towed M101A1	11,000 14,500 (RAP)	4,980	1	10	3	5 T Trk HELO	HE HE-RAP ICM HEAT-T HEP-T Smoke HC Smoke WP Illum APERS-T Leaflet Chemical-CS GB H	PD D VT MT CP MTSQ MAMT	33	TNT 20x30 COMP B 20x30
105mm Howitzer Towed M102	11,500 15,100 (RAP)	3,140	2	10	3 2 Rds/Min First 30 Min 1 RD/Min Thereafter	5/4 T Trk HELO				
155mm Howitzer Towed M198	18,150 Chg 8 24,000 Chg 8S 30,000 (RAP)	15,200	5	4	As Indicated By Thermal Warning Device	5-T Trk HELO (Ch-53 E Only)	HE HE RAP ICM CGLP Illum Atomic DPICM RAAM ADAM Smoke Smoke WP Chemical-GB VX HC	PD D UT MT CP MTSQ	95	30x50
155mm Howitzer Towed M114A2	14,600 19,400 (RAP)	12,700	3½	4	1	5-T TRK HELO (Ch-53)				
155mm Howitzer SP M109A1/ A2/A3	14,600 Chg 7 18.100 Chg 8 23,500 (RAP)	53,940	½	4	1 (CHG 1-7) CH 8: 1 rd/min for first 60 min then 1 rd/3 min	SP				
8 in. Howitzer SP M110A1/ A2	16,800 20,600 Chg 7 22,900 Chg 8 30,000 RAP	62,100	3	1.5	0.5	SP	HE HE-Spotting Atomic HE-RAP ICM GB Chemical-VX	PD D VT MT CP MTSQ	200	30x80
175mm Gun BP M107	32,800	62,100	3	1.5	0.5	SP	HE PP ICM	PD D VT	147	35x95
81mm Mortar	4,850	98	1	10		Man Pack	HE WP Illum	PD UT D TI	9	34x30
107mm Mortar	5,650	670	1			Man Pack	HE Chem WP (CS) Illum	PD VT D TI	35	20x40

CALIBER	# OF WPS PER BTRY	SHEAF WIDTH (METERS)	SHEAF FRONT (METERS)
105mm Howitzer	6	150	180
155mm Howitzer	6	250	300
8 in Howitzer	6	400	480
175mm Gun	6	475	570

Notes:

1. Maximum ranges are for standard HE projectile only — other projectiles may vary.
2. All projectiles are not compatible with all models.
3. All fuzes are not compatible with all projectiles.

Figure C-1. Artillery Weapon Characteristics (Sheet 1 of 2)

Abbreviations:

ADAM – Area Denial Artillery Munitions
APERS – T-Anti-Personnel-Tracer (FLECHETTE)
BD – Base Detonating
CLGP – Cannon Launched Guided Projectile (Copperhead)
CP – Concrete Piercing
CS – Riot Control Agent
D – Delay
DPICM – Dual Purpose Improved Conventional Munitions
GB – Non Persistent Toxic (Casualty) Nerve Gas
H – Mustard Gas
HC – Hexachloroethane (Smoke)
HD – Distilled Mustard Gas
HE – High Explosive
HEAT – High Explosive Anti-Tank w/Tracer
HEP-T – High Explosive Plastic w/Tracer
ICM – Improved Conventional Munitions
ILLUM – Illuminating
LBS – Pounds
M – Meters
MAMT – Muzzle Action Mechanical Time
MT – Mechanical Time
MTSQ – Mechanical Time Super Quick
RAP – Rocket Assisted Projectile
RAAMS – Remote Anti-Armor Mine System
RDS/MIN – Rounds Per Minute
PD – Point Detonating (Quick)
SP – Self Propelled
T – Ton or with Tracer
TRK – Truck
VT – Variable Time (Proximity)
VX – Persistent Toxic (Casualty) Nerve Gas
WP – White Phosphorus

Figure C-1. Artillery Weapon Characterisitcs (Sheet 2 of 2)

C.1.3 Artillery Ammunition Characteristics. A complete round of artillery ammunition contains all of the components necessary to propel the projectile from the weapon and cause it to burst at the desired time and place. The components are the primer, propelling charge, projectile, and fuze. Since choice of the proper projectile and fuzing is essential to mission success, the aircrew must be familiar with the following ammunition characteristics.

C.1.3.1 Shell HE, Fuze-Quick. Fuze-quick causes the projectile to burst on impact. Shell fragmentation is very effective against personnel standing, against personnel prone on open ground, and against unarmored vehicles and light material. Terrain has little effect on the ability to obtain fuze-quick bursts. In heavy jungles, there may be a number of tree bursts. It is also very effective in high-angle fire. With heavy artillery, fuze-quick may be used in indirect fire for destruction of armored vehicles.

There is very little effect against personnel in deep foxholes or trenches. The effect is greatly reduced if the ground is uneven or if shallow trenches are available. Little damage is done to frame buildings or earthworks.

C.1.3.2 Shell HE, Fuze Delay. The standard fuze delay with a .05-second delay element is normally used for either ricochet fire or penetration. A mixture of quick and delay is most effective against light frame houses and unarmored material, and in dense woods.

C.1.3.2.1 Ricochet Fire. Ricochet action depends on the angle of impact (small), the terminal velocity of the projectile, and the nature of soil (not too soft) at the point of impact. When used for ricochet fire, fuze delay has several peculiarities. The height of burst is somewhat less than airbursts obtained with fuze time or fuze VT; this greatly reduces the effect of the shell against deeply entrenched targets. However, for targets in shallow trenches, the effect is somewhat better than that obtained from time fuze airbursts; the height of burst is lower and the projectile is in a different (nose up) attitude. Fuze delay (ricochet) is more effective than fuze-quick against personnel in shielded areas (shallow foxholes).

The unpredictability of fuze action restricts the use of ricochet fire for neutralization. The higher the charge, the smaller the angle of impact; and the harder the ground at the point of impact, the better the chance of obtaining ricochets.

If the shell does not ricochet, mine action may result, making the round useless against most targets. Delay fuze of ricochet action should not be used against standing or prone troops in the open. Use fuze-quick instead.

C.1.3.2.2 Penetration. Penetration with delay fuze is effective against light earthworks, against unarmored vehicles, and, with the larger calibers, against sturdy houses (such as brick and stone) and heavier earthworks.

Fuze delay is not effective against concrete or heavy masonary; the fuze is crushed before the delay element can function, resulting in a low order burst of little effect.

C.1.3.3 Shell HE, Fuze Mechanical Time SuperQuick (MTSQ). MTSQ fuzes can be set to detonate the shell at a given time along its trajectory. Normally, this type fuze is used to obtain airbursts over personnel. The height of burst can be controlled to produce any desired mean height of burst. Though not as effective as quick or delay fuze action against unarmored vehicles or light material, time fire is more effective for killing the personnel in such vehicles or those riding on tanks. It is very effective against personnel in the open, in trenches, or in deep foxholes.

MTSQ is very ineffective in high-angle fire because of the large height-of-burst probable error involved in long times of flight. Also, the necessity for determining and setting the appropriate fuze setting results in time fire being slower than other types of fire. MTSQ has a backup, quick action feature that causes the shell to detonate upon impact.

C.1.3.4 Shell HE, Fuze VT. The proximity (VT) fuze is a radio-activated fuze that functions at a predetermined distance from any object. Thus, height of burst is automatically controlled.

The VT fuze combines some of the advantages of both quick and time fuzes. Since the adjustment is performed with fuze-quick and the height of burst is automatic, the ease and rapidity of adjustment are the same as for fuze-quick. The fragmentation is similar to that of fuze time and is especially effective against entrenched personnel. It is the only fuze that will give effective airbursts with high-angle fire. In addition, the automatic height of burst permits effective surprise and unobserved fire.

Certain types of VT fuzes are not recommended when the trajectory passes through visible moisture or if the target is on water, snow, or ice. A good target description will enable the fire direction officer (FDO) in the fire direction center (FDC) to determine which VT fuze is most appropriate.

C.1.3.5 Shell HE, Fuze Concrete-Piercing (CP). These fuzes are constructed especially for use against concrete targets. Since it has a greater resistance to shock than the delay fuze, fuze CP should be used against hard surfaces, especially with weapons that will produce a high terminal velocity. The fuze is not used for area neutralization fire.

C.1.3.6 Shell ICM (Improved Conventional Munitions). The ICM round is an HE, base-ejection type of projectile that consists of a mechanical time fuze and a body assembly with small grenades. When the fuze functions, the grenades are ejected to the rear. Centrifugal force disperses the grenades radially from the projectile line flight. There are two types of ICM projectiles. The antipersonnel round (APERS ICM) uses a grenade in the form of a steel ball filled with explosives. When the grenade strikes the ground, a small charge ejects the ball 5 to 6 feet into the air where it detonates and scatters fragments over the target area. The number of grenades in each round depends on the caliber of the projectile; the 105-mm projectile contains 18 grenades, the 155-mm projectile carries 60 grenades, and the 8-inch projectile contains 104 grenades.

The antipersonnel/antimaterial round (DPICM) employs a dual purpose grenade. The grenade has a high explosive shaped charge that is effective against both material and personnel. There are 88 shaped charge grenades in a 155-mm round and 195 grenades in the 8-inch DPICM round.

C.1.3.7 Shell White Phosphorous, Fuze-Quick, Delay, MTSQ, or VT. Shell white phosphorous (WP) is used for incendiary, casualty-producing, marking, and screening purposes. In appearance, the burst of shell WP armed with fuze-quick is characterized by a fountain of brilliant white smoke and burning phosphorous. Small particles of burning phosphorous spread upward and outward as a pillar of smoke forms and rises. In all four roles of the white phosphorous shell (i.e., incendiary, casualty producing, marking, and screening), fuze-quick is usually preferable to fuze delay, VT, or MTSQ. However, when employed in the attack of a frame building, some projectiles should be armed with fuze delay so that they penetrate the walls and roof before detonating.

C.1.3.8 Shell Smoke Base-Ejection. Shell smoke is a base-ejection (BE) type of projectile that is filled with canisters containing smoke. The shell is always fuzed with a time fuze. Smoke is used for screening friendly movement, to obscure enemy vision, and for identification (marking). In appearance, the smoke shell is characterized by a small burst in the air which forces the canisters of smoke out of the projectile through its base. The ignited smoke canisters hit the ground and emit streams of smoke. The base-ejection smoke shell with time fuze is more effective as a screening agent than the white phosphorous smoke shell because it has less tendency to pillar and the smoke screen lasts longer. It is important to obtain airbursts when the smoke shell is employed. If the fuze is allowed to function too low, the smoke-producing effect of the shell will be reduced considerably. The direction of the wind must be considered in the employment of the smoke shell. If the shell impacts the ground prior to fuze functioning, the round will not function because the fuze supplied has no super-quick backup action.

C.1.3.9 Shell Illuminating. The illuminating shell is a base-ejection type of projectile containing a cylindrical flare attached to a parachute. It is armed with a time fuze and has an expelling charge that ignites the flare and ejects the flare and parachute from the base of the shell. The flare attains full illumination about 10 seconds after being ejected and burns for about 60 to 120 seconds. The ejection of the flare and parachute at a height of 600 to 750 meters produces optimum illumination of the target area. When illuminating enemy forces, exercise caution to ensure that friendly troops are not exposed to enemy observation. Refer to Figure C-2 for the capabilities of various illumination rounds.

C.1.3.10 High Explosive (HE) Rocket Assisted Projectile (RAP). This HE shell has all the basic characteristics of the standard HE projectile but can be fired at greater ranges. A small rocket motor ignites along the trajectory giving the projectile the extended range.

C.1.3.11 Leaflet (Propaganda). A base-ejected shell can be filled with literature and used as a propaganda-type projectile.

C.1.3.12 Cannon Launched Guided Projectile (CLGP). The CLGP is an artillery projectile with terminal homing capability. It is used to destroy or neutralize hard point targets such as tanks or field fortifications. The targets must be designated/illuminated with a laser which will provide the reflected energy to allow the projectile to home in on the target.

C.1.3.13 Family of Scatterable Mines (FASCAM). Two artillery-delivered mine systems are now available: the Area Denial Antipersonnel Mine (ADAM) and the Remote-Antiarmor-Mine System (RAAMS). As their names imply, the ADAM is an antipersonnel mine designed to attack dismounted enemy forces and the RAAMS is designed to deliver antitank/antivehicle mines against the enemy armored/mechanized threat. Both systems have a self-destruct capability. The ADAM mines are within a few seconds of hitting the ground and, when disturbed, will eject into the air and explode. The RAAMS mine

Cannon	Projectile	Initial Height of Burst (Meters)	Distance Between Bursts (Spread) (Meters)	Burning Time (Seconds)	Rate of Continuous Illumination (Rounds Per Minute)	Rate of Fall (Meters Per Second)
105mm	M314A2	750	800	60	2	10
105mm	M314A3	750	800	70-75	2	10
155mm	M118	750	800	60	2	10
155mm	M485A2	600	1000	120	1	5

Figure C-2. Employment Factors for Illuminating Shells contains a magnetic influence fuze and is capable of destroying a tank.

C.1.3.14 Antipersonnel (APERS-Flechette). The APERS or beehive round is primarily intended for antipersonnel use. The projectile body is loaded with 8,000 steel flechettes (darts) that are especially effective against personnel in the open or in dense foliage. Although the weapon is primarily designed for position area defense and short ranges, the time fuze makes it effective at greater ranges, also. The APERS is available in 105 mm only.

C.1.3.15 Chemical. Both toxic and nontoxic chemical munitions are available for the field artillery. Some of these chemical agents include riot control (CS), nerve gas, and mustard gas. A new binary chemical projectile will soon be available. It is designed so the chemicals are not mixed into a lethal dose until the round is prepared and fired to the target. The advantage of this type of round is its stability and the safety afforded friendly personnel during storage and handling.

C.1.3.16 High Explosive Antitank-Tracer (HEAT-T). The antitank round is only found in 105 mm. It is designed with a shaped charge and is specifically intended for use against tanks and other armored vehicles. It is used in the direct fire mode only.

C.1.3.17 Nuclear. Tactical nuclear projectiles are available for 155-mm and 8-inch artillery weapons. Before an artillery unit is certified capable of handling, transporting, and firing nuclear weapons, it must successfully complete an inspection which demonstrates its proficiency to perform the required functions. Throughout the nuclear program, strict safety regulations are followed to eliminate the accidental or unauthorized detonation of nuclear weapons.

C.1.4 Artillery Communications. The aircrew usually conducts artillery missions over the air spot net. There may be occasions when the air spot net is unusable or the traffic is inappropriate for that net. The aircrew should therefore have a working knowledge of artillery communications to facilitate the use of alternate nets.

The artillery communications system is an integration of radio, wire, multichannel radio, and teletype subsystems.

At the artillery regimental level, internal communications are established and maintained on the following nets:

1. Command
2. Tactical
3. Fire direction
4. Artillery radar telling
5. Artillery air spot
6. Artillery survey
7. Artillery metro.

The requirements for communications external to the artillery regiment are outlined in FMFM 10-1, Communications.

The conduct of fire net is used by the forward observers to request and adjust artillery fires. The conduct of fire net will terminate in the battalion or battery fire direction center depending on the degree of centralized control.

The artillery air spot net provides a means for aerial observers to transmit target information to artillery units and to adjust fires. Multiple air spot nets are generally required.

C.1.5 Artillery Fire Planning and Request Channels. Aircrew in support of maneuver units will encounter targets of opportunity which will be engaged immediately. They will also acquire targets upon which fires will be planned for engagement at some time in the future. The aircrew is thus actively involved in the fire planning process and should have a working knowledge of artillery fire planning channels. The following paragraphs assume that such analysis and assignment has taken place and will then outline the fire planning channels followed for targets assigned to artillery.

C.1.5.1 Rifle Company Level. The artillery forward observer, along with his fire support personnel (81-mm mortar FO, NGF spotter, FAC), is briefed by the company commander concerning the company's mission, scheme of maneuver, and concept of fire support. Using the information obtained at the briefing, the FO plans artillery fires. He takes into consideration the areas of target planning and the phases of fires discussed in previous paragraphs. These fires are planned without respect to unit boundaries. The FO prepares a list of targets, submits it to the company commander for approval, then forwards it to the artillery liaison officer at the infantry battalion FSCC. The list of targets may be a written list delivered by hand, it may be accompanied by an overlay, or it may be transmitted by radio or wire communications. Targets will be given ABCA numbers by the artillery liaison officer after he consolidates the lists of targets for all FOs with the battalion.

C.1.5.2 Infantry Battalion Level. The fire support coordinator (FSC), with the infantry battalion, supervises the preparation of a list of targets for the battalion. These targets are derived from input from the S-2, the scheme of maneuver developed by the S-3, the rifle companies, and from the commander's guidance. Duplications are resolved, the list is consolidated, target numbers are assigned, and the various targets are assigned to supporting arms. Once the initial plan has the approval of the S-3 and/or the battalion commander, the artillery liaison officer forwards the artillery targets to the artillery battalion FDC and regimental FSCC. His forward observers are then informed of the final decision regarding their targets.

C.1.5.3 Infantry Regimental Level. A nearly identical process takes place at the FSCC of the infantry regiment. Targets received from the S-3, S-2, regimental commander, and the maneuver battalions are consolidated and forwarded to the appropriate agencies, to include the division FSCC. The artillery liaison officer sends the entire list of artillery targets to his battalion FDC, where personnel have already begun planning in response to the early input from the battalions.

C.1.5.4 Artillery Battalion FDC. The FDC of the artillery battalion in direct support is the focal point for artillery fire planning for the infantry regiment. The artillery battalion S-3 consolidates the target requests received from the regimental FSCC, combines them with input from his S-2 and from higher headquarters, and prepares the artillery fire plan for the infantry regiment. His fire plan is returned to the regimental FSCC for approval, and an additional copy is forwarded to the artillery regimental FDC for information, requesting additional artillery support, and ultimate consolidation at the division FSCC.

C.1.5.5 Artillery Regiment FDC. Fire planning at this level involves mainly the use of artillery units assigned a tactical mission of general support of the division. The artillery regimental S-3 prepares the artillery fire plan for the division. This plan includes the additional requirements initiated by the artillery battalion's request for long-range and reinforcing fires, the desires of the division commander, and the resolution of duplications arising from the total fire planning effort of the division. The division plan neither includes nor repeats the fire plans of the infantry regiments. Request for general support, general support-reinforcing, or reinforcing fires is forwarded to the general support battalion of the artillery regiment. The regimental FDC will plan the fires of the general support and reinforcing artillery. All fires planned at the regimental FDC which fall within the zone of a lower echelon and the targets included on the target lists are incorporated into an artillery fire plan. The completed fire plan is sent to division FSCC for approval by the division commander. The approved plan is then *shotgunned* to direct support, general support, general support/reinforcing, and reinforcing artillery units.

C.1.5.6 Final Target Analysis. A final note of importance in regard to artillery fire planning is required. Although targets generated and/or analyzed in the FSCC may be assigned to the artillery, it is in the artillery FDC that final target analysis takes place. The artillery S-3 (fire direction officer) assigns the unit to fire on the target and determines the best ammunition and method of fire to achieve the desired effect on the target.

C.1.5.7 Artillery Support Request. As with all supporting arms, a request for artillery support will be approved most rapidly when it is submitted to the proper agencies. The artillery air spot net is the primary channel for operational control by the aircrew. It is normally located in the FDC of the senior artillery headquarters, but can also be found in the division headquarters and artillery battalions and batteries as required. The aircrew will contact the FDC for instructions and mission approval. Once the mission is approved by the FDO, the mission is conducted in a manner similar to that of a ground observer.

C.1.6 Artillery Call For Fire. After locating the target, the observer must send the location to the fire direction center (FDC). The fire direction center will convert the observer's target data into firing data for the guns. The observer's message is divided into six elements, some of which contain several subelements. Depending on the situation, some of these elements and subelements may be unnecessary and can be omitted. The complete message is referred to as a *call for fire*. It is important to include all the elements of the call for fire in the proper sequence. A normal call for fire contains six elements and is transmitted in a maximum of three parts with a break and readback after each part. A typical call for fire is shown in Figure C-3 and an example airspot kneeboard card is found in Figure C-4.

1. The first transmission announces the OBSERVER IDENTIFICATION and the WARNING ORDER.

2. The TARGET LOCATION is identified in the second transmission.

3. The TARGET DESCRIPTION, METHOD OF ENGAGEMENT, and METHOD OF FIRE AND CONTROL are included in the third transmission.

C.1.6.1 Identification of Observer. The observer identifies himself by his radio call sign.

C.1.6.2 Warning Order. The warning order alerts the FDC that a fire mission is to follow. The mission will have priority on channels of communication. The three elements of the warning order alert the FDC to the relative urgency of the mission, whether massed fire is required, and the method the observer is going to use to locate the target. This warning order gives the fire direction officer (FDO) the necessary information he needs to assess priorities. It also helps the chart operators and computers prepare to receive the next element in the call for fire - the target location.

C.1.6.2.1 Type of Mission. A fire mission may be one of four types.

1. Immediate suppression - the maneuver force is taking fire and urgently needs suppressive fire. In this case, the observer will announce "immediate suppression" followed by the target number or location.

2. Suppression - fire is needed on a planned target or checkpoint which, if occupied by the enemy, could jeopardize freedom of movement or accomplishment of the mission. A suppression mission is fired on a planned target that is not currently active.

ELEMENT	EXAMPLE
1. OBSERVER IDENTIFICATION	"T1F THIS IS C2L"
2. WARNING ORDER	"ADJUST FIRE, OVER"
READBACK	"C2L THIS IS T1F ADJUST FIRE OUT"
3. TARGET LOCATION	"GRID 934125 OVER"
READBACK	"GRID 934125 OUT"
4. TARGET DESCRIPTION	"10 TROOPS DIGGING IN"
5. METHOD OF ENGAGEMENT	"VT IN EFFECT"
6. METHOD OF FIRE AND CONTROL	"AT MY COMMAND, OVER"
READBACK	"10 TROOPS DIGGING IN, VT IN EFFECT, AT MY COMMAND, OVER"
MESSAGE TO OBSERVER	"T1F – 4 ROUNDS, TIME OF FLIGHT 24 (SEC), MAX ORD 2,000 FEET MSL OVER"
OBSERVER READBACK	"T1F – 4 ROUNDS, TIME OF FLIGHT 24, MAX ORD 2,000 FEET MSL, OUT"

Figure C-3. Example Artillery Call-for-Fire

3. Fire for effect – the observer is certain of the target location and does not desire to lose the element of surprise by unnecessary adjustments.

4. Adjust fire – if the observer is not confident of the location of the target, he warns the FDC by announcing that he plans to adjust onto the target.

C.1.6.2.2 Size of Element to Fire. If the observer intends to mass the fire of multiple units, he alerts the FDO to this fact in his warning order. In this case, the observer will announce "request reinforcing" or "all available" if he intends to fire for effect with more than a single battery.

C.1.6.2.3 Method of Target Location. If the observer has located the target by polar plot or shift from a known point, he alerts the chart operator in his warning order. The word "polar" is announced if the observer is using the polar plot method of target location. If the method of target location is shift from a known point, the observer announces "shift" followed by the known point. Example: SIJ, THIS IS B3H BN SHIFT AB2001, OVER. If neither shift nor polar are announced, it is assumed that the grid method will be used.

C.1.6.3 Target Location. Target location may be reported in several ways, all of which must include a ground/map reference and the direction of the spotting line.

1. Grid coordinates - the target location is normally reported to the nearest 100 meters (6 place grid) when using grid coordinates. To indicate that coordinates are being used, the observer will announce "grid." Example: GRID YC 13567189. The altitude of the target is not reported by the observer since it will be determined by the FDC. Known point such as an oncall target may also be sent if the observer is certain the FDC has the location of those points available to it. The observer-target (OT) direction need not be sent until the subsequent corrections are given.

2. Shift from a known point - if "shift" is announced in the warning order, the point from which the shift will be made is also announced as part of the warning order. For the target location the observer will send the OT direction. The OT direction, in this case, is from the observer to the known point. The OT direction should be expressed to the nearest 10 mils or 10°. Other methods of announcing OT direction such as cardinal direction or gun target line may also be used. In any case, the observer must identify what he is using to measure the OT direction. Next, the lateral shift "left" or "right" is announced. The lateral shift is expressed to the nearest 10 meters. The range shift, either "add" or "drop," is then announced. Range shifts are expressed to the nearest 100 meters. If there is an obvious difference between the altitude of the target and that of the known point, a vertical shift is also announced by giving either an "up" or "down" correction. Example: DIRECTION 280°, MAGNETIC, LEFT 140, ADD 400, UP 35. When no maps are available and there has been no previous firing in an area, the observer may request "mark center of sector," and then shift from the marking rounds.

3. Target number - when the location of a target has been established by the FDC personnel and the observer prior to a flight, a target number may be given to it. In this case, the observer needs only to transmit the target number for his target location. Example: TARGET AF2010. In this case, the artillery target list must be made available to the AO prior to launch. The polar plot method is rarely used, but it can be done by creating a "false OP" point on the ground which the observer uses to locate the target. The target will be located by announcing a direction to the nearest 10 mils, distance to the nearest 100 meters, and a vertical shift to the nearest 5 meters from the false OP. The FDC must know this location if polar is to be used. This technique may be useful for the aerial observer, but make sure the FDC understands your transmission. This may require additional coordination and communication between the observer and the FDC since this technique is not routinely practiced. Example: R1S, THIS IS H3E, ADJUST FIRE POLAR, OVER. FROM TARGET AB2411 DIRECTION 320°, DISTANCE 1,200 METERS, OVER. TANKS AND APC WITH TROOPS, DPICM IN EFFECT, OVER.

4. Direction - the aerial observer makes spottings and corrections with respect to a spotting line. The fire direction center must

1. Observer Identification

_______________ This is _______________

2. Warning Order
    - Adjust Fire
    - Fire for Effect
    - Suppress
    - Immediate Suppression
    - Size of Unit to Fire _______________
    - Method of Target Location – Grid/Shift (Identify Known Point)

3. Target Location (brief, accurate description of target)

    Grid _______________

Shift – OT Direction	Left/Right	Add/Drop	Up/Down
_______	_______	_______	_______

4. Target Description

5. Method of Engagement
    - Destruction
    - Area (Standard)
    - Danger Close (600M)
    - Trajectory – High Angle/Low Angle (Standard)

    Ammunition – Projectile _______ Fuze _______ #RDS IN FFE _______

    Distribution – Ranging Rounds/Request Splash/Maximum Ordinate/Time of Flight

6. Method of Fire and Control
    - Method of Fire
    - Method of Control – At My Command/Cannot Observe/Do Not Load/TOT

____

Message to Observer/Additional Information

1. Unit to Fire – Unit in FFE _______________ Adjusting Unit _______________
2. Changes
3. Rounds in FFE _______________
4. Time of Flight _______________ 5. Maximum Ordinate _______________
6. Probable Error _______________ 7. Angle T _______________
8. Target Number _______________

OT DIRECTION

GTL/Cardinal Direction _______________ /MILLS _______________ /Degrees _______

Other ____

Figure C-4. Example Airspot Kneeboard Card know the direction of the spotting line in order to orient the target grid on the firing chart. Since the observer is moving continuously, his spotting line on the ground must be easily identified and distinctly visible. The observer should select a prominent cultural or terrain feature near the target to facilitate the target and spotting line identification. There are several spotting lines which the observer may select for use in making his adjustments: the gun target line (GTLN), identifiable terrain feature, cardinal direction, grid or magnetic azimuth. The OT direction can be announced in mils (to the nearest 10 mils) or degrees (to the nearest 10°). If there will be any confusion as to whether the azimuth is grid or magnetic, it should be specified what kind of direction is given.

(a) Gun target line - this is an imaginary line from the firing unit to the target. If the observer knows the location of the weapons, visualization of the GTLN is facilitated. If he does not know the location of the weapons, the observer requests RANGING ROUNDS in the distribution of fire. These two rounds fired at the same deflection, but 400 meters apart in range, will enable the observer to visualize the GTLN. The rounds are fired at a 5-second interval with the initial round being fired at the reported location. This round will be known as the NEAR ROUND. The second round will be fired 400 meters beyond and is known as the FAR ROUND. The two terms will be used in the adjustment phase of the mission. These ranging rounds also serve as a "yardstick" for estimating subsequent range and deviation correction. Use of ranging rounds is normally undesirable, as it facilitates enemy acquisition of the battery's location. Once the observer determines the direction of the GTLN, he should select terrain or cultural features such as a road, stream, or ridgeline which will assist him in remembering the direction. If no spotting line is stated by the observer, the GTLN will be used in the FDC as the spotting line.

(b) Reference line identifiable terrain - the observer may select a line formed by a road, a railroad, a canal, or any series of objects. To use this line, the observer must describe it in detail to the FDC so that its direction may be determined. Example: DIRECTION HIGHWAY 1 FROM ONG BO BRIDGE TO KE HA BRIDGE.

(c) Cardinal direction - the cardinal points of a compass are sometimes used. If so, the cardinal direction should be converted to mils before announcing it to the FDC. Example: SOUTH = 3,200 MILs.

(d) The aircraft heading indicator may provide accurate direction in some cases. If the aircraft assumes a head-on posture, the reading on the heading indicator would indicate the observer-target (OT) line. The OT line is announced to the nearest 10° and is corrected if the OT direction changes by more than 10°. When making changes or subsequent corrections ensure the corrections are in relation to the new OT direction.

(e) The FLIR may also aid in computing OT direction by grid or magnetic azimuth.

C.1.6.4 Description of Target. This element contains a brief but accurate description of the target to include degree of protection, number of personnel and equipment, size and shape, and the nature of the target activity which is observed. The description should be brief and concise but sufficiently informative to enable the fire direction officer to determine the relative importance of the target and best manner of attack. Example: 50 INFANTRY, 2 TANKS AND 1 TRUCK IN OPEN, OR 2 MORTARS FIRING. It is not necessary to say "enemy squad in open" for it is taken for granted that the observer is not shooting at his own friendly troops. If the target area is very large, the observer may include the size in meters and the attitude of the long axis to the nearest 50 mils, or 15°. Example: 400 X 200 ATTITUDE 290°. When the target area is circular, the observer gives the radius. Linear targets may be described by two or more grids or by grid, length, and attitude.

C.1.6.5 Method of Engagement. This element is further broken down into five subelements which provide information regarding type of engagement, trajectory, ammunition, and distribution of fire desired by the observer.

1. Type of engagement - either of two types of adjustment may be employed: area or precision. Unless precision fire is specified, area fire will be used.

(a) Area fire is used for attacking a dispersed target. Since many area targets are capable of movement, the adjustment should be as rapid as possible, consistent with accuracy to prevent the target from escaping. The observer must select a well-defined point at or near the center of the area to be attacked. This is called the adjusting point. Normally, adjustment on an area target is conducted with one adjusting gun. The observer need not request this type fire. It can be omitted from his call for fire. To achieve surprise, fire may be adjusted onto an auxiliary adjusting point and then shifted to the target.

(b) Precision fire is conducted with one piece on a point target. It is used to either destroy the target or obtain registration corrections for the battery. Registrations are initiated by a message to observer from the FDC. If the target is to be destroyed, the observer will announce "destruction." This type of mission is very time-consuming and normally will be assigned to a forward observer on the ground. For detailed instruction on precision registration/destruction procedures, refer to FM 6-30.

(c) The term *danger close* is included in the method of engagement if the target is within 600 meters of friendly troops. For mortars, *danger close* is 400 meters. Along with the range element, the direction of the friendlies from the target should be given. In adjusting artillery during a *danger close* mission, the *creeping* method vice *bracketing* should be applied. This entails correction of no more than 100 meters as the rounds are moved toward the enemy position when they are within 600 meters of friendly positions. If no friendly troops are within 600 meters of the target, the observer will normally omit any reference to friendly troops from his call for fire. All weapons that will fire for effect will also fire in the adjustment phase of the mission.

(d) The term *mark* is used if the observer needs to orient himself in his zone of observation or to designate targets to ground troops, aircraft, or other fire support means. Example: MARK TARGET #AB6001 OR MARK CENTER OF SECTOR. Generally, unit SOP calls for shell WP with fuze-quick or time to be fired during these types of missions.

2. Type of trajectory - a choice of two trajectories normally is available, low angle or high angle. When low-angle fire is desired, this subelement is omitted. If the observer desires high-angle fire, he must announce HIGH ANGLE. When the observer omits a reference to trajectory, but computations in the FDC indicate high-angle fire to be necessary, the S-3 will notify the observer that high-angle fire will be used.

3. Ammunition - this subelement permits the observer to request the type of projectile and fuze action desired. If this subelement is omitted, the observer will receive shell high explosive and fuze-quick. The observer must

specify if he wants any shell fuze combination other than HE/Q. When the observer wants a combination of projectiles and/or fuzes in effect, he must so state in this subelement. Example: HE AND WP IN EFFECT AND/OR VT AND QUICK IN EFFECT. If the observer wants to adjust with one shell and fire for effect with another, he must so state. Example: WP IN ADJUSTMENT, HE, VT IN EFFECT. The observer may also indicate the volume of fire he considers necessary to accomplish the mission. For example, if the observer has requested the battalion fire for effect and considers three rounds of shell HE and WP as the desired volume, he would announce "HE and WP, in effect, 3 rounds."

4. Distribution of fire – this pertains to the sheaf in fire for effect. The term sheaf is used to denote the lateral distribution of the bursts of two or more pieces fired together. The width of the sheaf is the lateral distance (perpendicular to the direction of fire) between the center of the flank bursts. The front covered by any sheaf is the width of the sheaf plus the effective width of one burst. A parallel sheaf usually is fired on an area target in fire for effect and, therefore, need not be announced. When another type of sheaf is desired, the observer must so announce. Example: CONVERGE OR OPEN SHEAF 100 METERS. If the observer desires to spread the fires of a battalion, he will request either RANGE SPREAD or LATERAL SPREAD. The standard spread for a battalion is 100 meters between firing batteries.

C.1.6.6 Method of Fire and Control. This element indicates the manner in which the observer will attack the target, whether or not he desires to control the time of delivery and whether or not he can observe the target.

1. Method of fire – in an area of fire, the adjustment normally is conducted with the one centerpiece of the adjusting battery. If, for any reason, the observer desires the weapons to fire from left to right, he must announce "platoon left" or "platoon right." In a platoon right (left) the rounds are fired from the right (left) side toward the left (right) side. The normal interval of time between rounds fired by a platoon or battery right or left is 5 seconds. If the observer wants some other interval, he may so specify. Battery rights or lefts are very useful in checking a battery sheaf for howitzers shooting unusually short or long.

(2) Method of control – the control element indicates the control which the observer will exercise over the time of delivery of fire and whether an adjustment is to be made or fire is to be delivered without adjustment. Method of control is announced by the observer using one or more of the following terms.

(a) At my command (AMC) – this phrase indicates that the observer desires to control the time of delivery of fire. The observer announces "at my command." When the pieces are ready to fire, the FDC personnel announces "ready" to the observer who announces "fire" when he is in position to observe the rounds impacting. AMC remains in effect until the observer announces "cancel at my command."

(b) Cannot observe – this phrase indicates that the observer is unable to adjust fire; however, he has reason to believe that a target exists at the given location, and that it is of sufficient importance to justify firing on it without adjustment.

(c) Time on target (TOT) – this phrase tells the FDC when the observer wants the rounds to impact around the target by requesting: "Time on Target 22 minutes from ... now, over" or "Time on target 0800 over." If the second technique is used, remember to contact the FDC for a time check.

(d) Time to target (TTT) is used to request artillery in conjunction with a close air support strike (marking rounds or SEAD). In this case, the artillery mark will land in the target area 20 to 30 seconds prior to the aircraft time to target. In this case, the TTT refers to the aircraft TTT and not an artillery TOT.

(e) Fire when ready - if nothing is specified regarding method of control, each cannon section will fire when ready.

(f) Continuous illumination - if no interval is given by the observer, the FDC will determine the interval by the burning time of the illuminating ammunition in use. If any other interval is required, it will be indicated in seconds.

(g) Coordinated illumination - the observer may order the interval between illuminating and HE shells in seconds to achieve a time of arrival of the HE coincident with optimum illumination, or he may use normal "at my command" procedures.

(h) Cease loading - the command "cease loading" is used during firing of two or more rounds to indicate the suspension of inserting rounds into the gun(s).

(i) Check firing - this command is used to cause a temporary halt in firing.

(j) Continuous fire - in field artillery and naval gunfire, this means loading and firing as rapidly as possible consistent with accuracy within the prescribed rate of fire for the equipment. Firing will continue until temporarily suspended by the command "cease loading" or "check firing."

(k) Followed by - this is part of a term used to indicate a change in the rate of fire, in the type of ammunition, or in another order for fire for effect.

(l) Repeat -

During adjustment. Fire another round(s) at the last data, for any change in ammunition if necessary.

During fire for effect. Fire the same number of rounds at the same method of fire for effect as last ordered. Alterations to the number of guns, the gun data, the interval, or the ammunition may be ordered.

C.1.6.7 Corrections of Errors in Call for Fire. Errors may be made by the observer transmitting erroneous data or by the FDC personnel transmitting an incorrect read-back. If an observer realizes that he has made an error in his transmission, he announces "correction" and transmits the corrected data. If the observer notes the FDC read-back is incorrect, he announces "correction" and transmits the corrected data. When an observer sends erroneous data in subsequent corrections which are related to target location, such as deviation, range, or height of burst, he corrects the errors by announcing "correction" followed by the entire correct target location. For example, if the observer has transmitted "left 200 and add 400," and he desires to change "add 400" to "drop 400," he sends "correction, left 200, drop 400." The word "correction" in this case cancels the entire previous target location. If anything unrelated to target location is omitted or transmitted in error, the observer announces "correction" and transmits the omitted element or retransmits correctly the element erroneously transmitted. The remainder of the call for fire is not transmitted. For example, after the observer has transmitted "smoke, right 200, add 400, up 20," he realizes he should have requested WP instead of shell smoke; therefore, he only announces "correction WP."

C.1.6.8 Message to Observer. After the FDC has received the observer's call for fire, the fire direction officer will make a decision on how he wants to attack the target, and the FDC personnel will begin to compute firing data for the guns. Shortly after a decision to fire the mission has been made, the FDC will furnish the observer with a "message to observer." The MTO consists of the following elements:

1. Unit to fire - this element consists of the battery or batteries to fire for effect.

2. Adjusting battery - this element is included if more than one battery is firing for effect.

3. Changes - any changes or additions to the elements requested by the observer in the call for fire will be included in this element.

4. Rounds - this element contains the rounds per tube to be expended in fire for effect. If the observer receives 3 rounds in this element, he should observe 18 rounds impacting during fire for effect providing he is receiving a full six-gun battery.

C.1.6.9 Additional Information. It may also be necessary for the FDC to pass additional information regarding the mission to the observer. If required, the following information may be sent separately from the message to observer.

1. Time of flight - the time of flight is sent to the aerial observer to facilitate aircraft orientation. This indicates the time in seconds for a projectile being fired to its impact. If the time of flight changes more than 5 seconds from that originally announced, the new time of flight will be announced. Five seconds before the round impacts, FDC will announce "splash" to the observer.

2. Probable error - if the probable error is greater than 38 meters, then the FDC will announce it in the message to observer. The observer should not attempt to split a 100-meter bracket in this case as only 50 percent of his rounds will impact within 1 probable error over and short on the GTL of where they should.

3. Angle "T" - if the observer is using a reference line other than the GTL for adjustments, the FDC will report the angle "T" if in excess of 500 mils, or when requested by the observer.

4. Target number - if a target has been recorded, the FDC will send the observer the replot grid as soon as available. Target numbers will not be assigned to targets of opportunity unless:

(a) The observer requests it (and the FDO agrees).

(b) The FDO (or FSCC) directs that it be recorded as a target.

(c) The target number will be sent at the completion of the mission.

C.1.7 Adjustment Techniques (Area Fire). During the conduct of area fire missions one of several adjustment techniques may be employed.

1. After the first definite range spotting, the observer will send a correction to the FDC to establish a bracket around the adjusting point. If the "successive bracketing" technique is used, the observer will successfully split the bracket until the next correction will bring the rounds within 50 meters of the adjusting point, at which point he will enter FFE.

2. If the observer is more experienced or time is critical, the observer may use the "hasty bracketing" technique. After the initial range bracket is established, the observer will determine one subsequent correction and enter FFE.

3. The *one round adjustment* technique does not require the establishment of a range bracket. After the initial round the observer will transmit the correction necessary to move rounds to the adjusting point and enter FFE.

4. Auxiliary aiming point - to achieve maximum benefit from the element of surprise, the observer may utilize an adjustment technique that incorporates an auxiliary aiming point or auxiliary adjusting point. What the observer does in this case is adjust onto a point near the target but far enough away that the enemy does not realize what the actual target is. Once adjusted onto the auxiliary adjusting point, the observer makes one final bold shift and enters fire for effect. Caution must be taken to ensure that an accurate (preferably lateral) shift can be made. A shift too large may cause inaccuracies that may result in little or no effect on the target.

5. Creeping fire - is used during danger close missions and involves use of small corrections that progressively creep toward the adjusting point. It is used when care must be taken to ensure safety for friendly troops.

C.1.7.1 Desired Effects. Once the observer has located a target, he must decide how he wants to attack the target to get maximum effect. A thorough knowledge of the ammunition available to him will allow a rapid selection of the correct type of shell and fuze to use against the target. If not specified by the commander's guidance, the first decision the observer must make is what type of effect he desires. He has three choices: destruction, neutralization, or suppression.

Destruction puts a target out of action permanently. Thirty percent or more casualties will normally render a unit combat ineffective. Direct hits with HE or CP shells are required to destroy hard material targets. Destruction usually requires large expenditures of ammunition and is not considered an economical mission.

Neutralization knocks a target out of action temporarily. Ten percent or more casualties will neutralize a unit. Neutralization can be achieved using any type shell/fuze combination suitable for attacking a particular type target. Neutralization does not require an extensive expenditure of ammunition and is the most practical type mission.

Suppression of a target limits the ability of the enemy personnel in the target area to perform their jobs. Firing HE/VT or smoke creates apprehension and confuses the enemy. The effect of suppressive fires usually lasts only as long as the fires are continued. Suppression requires a low expenditure of ammunition; however, its inability to place lasting effect on a target makes it an unsuitable type mission for most targets.

To decide whether to use impact fuze action (produces ground bursts) or time fuze action (produces airbursts), the observer should consider:

1. The nature of the target
2. The cover available to the enemy
3. The mobility of the target
4. Whether or not adjustment is required.

For a thorough discussion of munitions effects and examples of optimum shell fuze combinations for particular targets, see FM 6-30.

C.1.7.2 Fire For Effect (FFE). (See Figure C-5). In area fire, fire for effect is started when a suitable adjustment has been obtained; that is, when deviation and range are correct or when splitting the range bracket will produce effective fire.

Fire for effect is not to be started if the last rounds observed were all graze bursts. If

RESULTS OF FFE	OBSERVER'S ACTIONS
1. ACCURATE AND SUFFICIENT	EM, SURVEILLANCE, (END OF MISSION, RPG SILENCED)
2. ACCURATE, SUFFICIENT, TARGET REPLOT DESIRED	REQUEST REPLOT, EM, SURVEILLANCE (RECORD AS TARGET, END OF MISSION, BMP NEUTRALIZED)
3. INACCURATE AND SUFFICIENT	REFINEMENT, EM, SURVEILLANCE (RIGHT 20 AND 20, END OF MISSION, RPG SILENCED)
4. INACCURATE, SUFFICIENT, TARGET REPLOT DESIRED	REFINEMENT, REQUEST REPLOT, EM, SURVEILLANCE (RIGHT 10 RECORD AS TARGET, END OF MISSION, BMP NEUTRALIZED)
5. INACCURATE AND INSUFFICIENT	REFINEMENT, REPEAT OR REENTER ADJUST FIRE (RIGHT 10 ADD 30 REPEAT)
6. ACCURATE AND INSUFFICIENT	REPEAT (REPEAT)

Figure C-5. Fire for Effect

ricochet action was sought in the adjustment, the use of fuze delay is continued in fire for effect when at least 50 percent of the bursts that established the 100-meter bracket were ricochets (airbursts). If less than 50 percent of the bursts were ricochet, fuze VT or quick is used in fire for effect.

If fire for effect is accurate but insufficient, the observer may announce "repeat." If any element of the adjustment (deviation, range, or height of burst) is in error enough to partially nullify the effectiveness of the fire for effect, the observer should correct the element or elements in error and continue the fire for effect; for example, add 50, down 10, repeat. If ricochet fuze action was sought in fire for effect and less than 50 percent of the bursts were ricochets, the fuze is changed to fuze VT or fuze-quick for subsequent fire for effect.

C.1.7.3 Computation and Announcement of Subsequent Corrections. After the spotting has been determined, it must be converted into corrections and transmitted to the FDC. Corrections are sent to the FDC in meters and announced in the following order: deviation, range, and HOB.

C.1.7.4 Deviation Corrections. The distance in meters that the burst center is to be moved for deviation is computed by multiplying the observer deviation in mils (the deviation spotting) by the OT distance in thousands of meters (the OT factor). The computed "correction" is announced to the fire direction center as "left" or "right" so many meters. The direction of the correction is opposite that of the spotting, and the correction is expressed to the nearest 10 meters.

C.1.7.5 Range Correction. After the first definite range spotting, the observer announces the range change as "add" or "drop" (so much) (in hundreds of meters). The range change must be the amount that is required to establish a range bracket. Once established, the existing range bracket is refined until it is narrowed to 100 meters. Fire for effect will begin at the center of a 100-meter bracket by the observer's correction "add/drop 50," "fire for effect." The observer can also enter FFE if he obtains a spotting of range correct.

C.1.7.6 HOB Corrections. With time fire, the air observer will have a difficult time determining the exact height of burst, but should, with practice, be able to differentiate an air and graze burst. When adjusting what appears to be a graze burst, the observer should give a bold correction, such as "up 40." When adjusting what appears to be an air burst, he may be able to make corrections based on actual effect on target.

C.1.7.7 Sequence of Subsequent Corrections. After the initial bursts appear, the observer will transmit changes in the call for fire and corrections for deviation, range, and height of burst as appropriate. Here are the subsequent corrections that may be necessary and the sequence they are transmitted in.

1. Whenever the "observer target direction" changes by more than 100 mils or 10° from that previously announced, the new OT direction must be announced.

2. If during the adjustments of artillery fires, correction is made that will cause the rounds to land within 600 meters of friendly troops, the observer would announce "danger close" as part of his subsequent corrections. If an adjustment moves the rounds more than 600 meters from friendlies, the observer would transmit "cancel danger close."

3. Whenever a change in trajectory is needed, the observer may change from low angle to high angle by announcing "high angle" or from high angle to low angle by transmitting "cancel high angle."

4. If the observer desires to change the "method of fire" he does so by simply transmitting the correction.

5. Whenever a change in "distribution" is in order, the observer will transmit the desired sheaf. If he is changing from a special sheaf to a parallel sheaf, the correction is made by announcing "cancel" followed by the type of sheaf being used.

6. In order to change the type of "projectile" being fired, the observer will announce the desired change.

7. Likewise, if the observer wants to change the "fuze" or "fuze action," he will announce the desired change.

8. To change the "volume of fire," the observer announces the change.

9. Corrections for deviation, range, and height of burst (HOB) are next in the sequence of subsequent corrections. If a correction for "deviation" is required to bring the bursts back to the observer target line, the observer will transmit "right/ left" followed by the deviation to the nearest 10 meters. If a correction for "range" is necessary, the observer will announce the correction as an "add" or "drop" so much. A correction for HOB is expressed to the nearest 5 meters and announced as an "up" or "down" correction. The desired HOB is 20 meters. In an area mission, HOB corrections are made after the deviation and range are corrected to within 50 meters of the target using fuze-quick in adjustments.

10. To change the method of control, the observer will transmit the desired method of control. To change the method of control from "at my command" the observer would transmit "cancel at my command."

11. The observer may request "splash" to help him identify the rounds being fired. The FDC will inform the observer that the rounds are about to impact by announcing "splash" 5 seconds prior to impact.

12. "Repeat" may be used during the adjustment phase or the fire for effect phase. If used during the adjustment, the firing unit will fire another round(s) at the last data fired. The observer may make adjustments in shell fuze combination only. Example: TIME REPEAT. If repeat is used, the firing unit will fire the same number of rounds at the same method of fire for effect as last ordered. Changes to number of guns, the gun data, the interval, or the ammunition may be made by the observer. Example: LEFT 20, ADD 200, ICM REPEAT.

C.1.7.8 Surveillance and Refinement Data. On completion of fire for effect (if the target has been neutralized and the fire was effective and sufficient), the observer will announce "end of mission" and report the effect observed: for example, "infantry dispersed." If the observer desires to make a correction to improve the accuracy of the replot of the target but does not wish to fire again, he will announce the correction; for example, left 20, followed by the words "end of mission" and the surveillance. There are, of course, several other combinations of surveillance and refinement possible.

C.1.8 Special Missions. The procedures previously discussed are common to all observed fire missions. Special consideration must be given to certain types of missions that employ ammunition other than HE. Some of the less frequently employed missions include the use of ICM, smoke, or illumination projectiles. Deviation shifts of less than 50 meters and range shifts of less than 100 meters should not be made. HOB corrections are made in increments of 50 meters and should be made only if more duds are observed or the effects pattern is too small. If ICM is used in a situation that requires the use of danger close, the observer must start at least 600 meters from friendlies and adjust with the entire battery. The adjustment should be made from the near edge of the effects pattern.

C.1.8.1 Family of Scatterable Mines (FASCAM). The observer techniques for FASCAM, ADAM, and RAAM are similar to the procedures used when adjusting ICM. If the mission requires observer adjustment, the round used in adjustment will be DPICM in the self-registration (SR) mode. The adjusting point or aimpoint is placed on the axis of advance at a distance of 1,000 mm in front of the enemy for every 10 km/hr or forward speed. If the target is stationary, the aimpoint is placed directly over the target center. The call for fire for FASCAM is similar to the call for fire for other projectiles with the following exceptions:

1. The warning order will include the type of projectile (ADAM, RAAM, or both).

2. If the target is located by grid coordinate at six places, grid is adequate.

3. Short self-destruct time is standard; if long self-destruct time is required, it must be requested (FFE, ADAM-6).

C.1.8.2 Illumination. Battlefield illumination has many uses in combat. It provides friendly forces with sufficient light to assist them in ground operations at night. When properly used, night illumination increases the morale of friendly forces, facilitates operations, and harasses and blinds the enemy.

The size of the area that can be effectively illuminated depends on the observer distance, conditions of visibility, and candlepower of the shell used. If the area to be illuminated is large or the observing conditions are poor, the firing of only one round of illuminating shell at a time may be inadequate. In order to provide various degrees of illumination, illumination missions may be fired with one gun; with two guns firing so that the rounds burst simultaneously at the same place; with two guns firing with a range or lateral spread between the bursts; or with four guns firing so that the bursts form a diamond pattern over the point of illumination. Two rounds bursting simultaneously at approximately the same place produce better lighting in an area than does one round. Two rounds may be used when observing conditions are poor because of haze, dust, or long observing ranges. The observer obtains this type of illumination by requesting "two guns" illumination in the call for fire.

For two rounds set to burst simultaneously in range (along the gun target line), the observer requests "illumination range spread." Two rounds fired at the same range with a lateral (deflection) spread will likewise give better illumination than one round, and will reduce the shadows resulting from a single flare. When this type of illumination is desired, the observer includes in his call for fire "illumination lateral spread." In this case, illumination given as the type projectile and range/lateral spread is given as the distribution. The distance between bursts in both cases will be 800 meters for 105-mm and 1,000 meters for 155-mm projectiles. For searching an area, the bursts from four pieces are placed 800 or 1,000 meters in a diamond pattern around the target. Two pieces will fire a lateral spread at the range to the area, and two pieces will fire a range spread at the deflection to the center of the area. To achieve this pattern, the observer requests "illumination, range, and lateral spread."

When the observer calls for a range or lateral spread or a diamond pattern, the FDC centers the pattern over the point indicated by the observer.

C.1.8.2.1 Subsequent Correction. The correct position of the flare to the adjusting point depends on the terrain and wind. The point of burst should be such that the final travel of the flare is not between the observer and the adjusting point. In a strong wind, the observer should place the point of bursts some distance from the adjusting point so that the flare will drift to the desired location near the target. Generally, the position of the flare should be slightly to one flank of the adjusting point and at approximately the same range. If the target is on a forward slope, the flare should be on the flank and at a slightly shorter range. If the adjusting point is a very prominent target, better visibility may be obtained if the flare is placed beyond the target to silhouette it.

Range and direction are adjusted by use of standard observed fire procedures with the minimum correction being 200 meters.

The height of burst is correct when the flare stops burning just before it strikes the ground. Changes in height of burst are made in multiples of 50 meters; for example, "down 100." The slight variations in the times of burning of flares render useless any closer adjustment of the height of burst. When the point of burst is too high, the required change is estimated from the height of the flare when it burned out. When the point of burst is too low, the required change is estimated from the length of time (T) in seconds the flare burned on the ground. The approximate rate of descent is 10 meters per second for the M134 (105 mm) and 5 meters per second for the M485 (155 mm). By multiplying "T" by 5 or 10, depending on the type of shell being fired, the observer can determine the approximate correction required for the height of burst.

C.1.8.2.2 Continuous Illumination. If the adjusting point is to be kept under illumination, the observer sends the request "continuous illumination." On receipt of this request, the FDC makes sure that a new shell bursts over the point indicated by the observer just before the burnout time of the old flare.

C.1.8.2.3 Coordinated Illumination. Coordinated illumination deals with the attack of targets with HE or other artillery ammunition during periods of darkness. To properly identify targets, observe the fires, and adjust the fires, coordinated illumination must be fired. For the most part, a coordinated illumination mission will start out as a basic adjust fire mission with shell "illumination" given for the type of projectile to be fired. After the illumination is adjusted to the point where a target suitable for attack by HE or other projectile can be observed, a coordinated illumination mission is initiated. These missions may be conducted in three different ways.

1. The FDC can control the firing of the HE so it arrives in the target area at the time of best visibility or maximum illumination. This is done by the observer announcing "coordinated illumination" in his call for fire. When the illumination in the target area is at its maximum, the observer will announce "illumination mark" to the FDC. This will enable the FDC to compute the correct time to fire the HE rounds so they arrive at the target during the period of best light.

2. "Coordinated illumination" is also announced for an alternate method of coordinating HE and illumination missions. However, this time the observer announces "by shell at my command" as the method of control. The primary difference between this procedure and the one previously discussed is that the FDC must inform the observer when both shell types are ready to fire. Then the observer will coordinate the fires by announcing "illumination fire" and a few seconds later he will command "HE, fire" so that the HE will arrive during the period of maximum illumination of the target.

3. A third method of coordination between HE and ILLUM fires is requesting "continuous illumination." For this method, the FDC will compute the interval required to maintain the proper level of illumination over the target and the battery will fire continuously while the observer adjusts the HE. This is the least desirable method because of the large amount of ammunition expended.

C.1.8.3 Smoke. If properly used, smoke projectiles can significantly reduce the enemy's effectiveness. The two basic smoke projectiles are HC and WP. The two primary purposes of smoke are to obscure enemy vision or to screen maneuver elements.

The observer must take several factors into consideration when using smoke.

1. Weather has a great influence on the effectiveness of smoke. Wind direction and speed, temperature, and humidity must all be considered.

2. The amount and type of ammunition available could have a significant impact on your ability to utilize smoke.

3. The terrain could influence the effectiveness of a smoke mission. Smoke seeks low spots, and canisters may roll downhill if fired into a steep terrain. In addition, smoke should not be used on deep mud, water, or snow as the canisters will not function properly.

4. A primary consideration for the observer is the commander's guidance. Remember that the commander must approve the employment of smoke. If improperly used, smoke could work to your disadvantage.

5. Enemy tactics, equipment, and capabilities must be considered. Smoke fired on enemy observation posts and flash ranging bases greatly reduces the effectiveness of their artillery. A combination of smoke and HE can be very useful in confusing the enemy, especially if he is changing tactical formations or transversing minefields.

Two basic adjustment techniques are used in the conduct of smoke missions.

1. An immediate mission is used to obscure the enemy's vision and is used primarily against small area or point targets. The conduct of smoke is similar to an immediate suppression mission and is largely based on local SOP. When adjusting immediate smoke, minimum correction for deviation is 50 meters and for range it is 100 meters.

HOB corrections are made in increments of 50 meters. The following guidelines are suggested for HOB adjustments:

(a) Groundburst - Up 100

(b) Canisters bouncing excessively - Up 50

(c) Canisters too spread out - Down 50

2. Quick smoke is used to obscure enemy vision or screen maneuver elements. The mission is begun by adjusting with HE and then shifting to smoke. Quick smoke will obscure a larger area, normally up to 600 meters, for a longer time than an immediate smoke mission. Larger areas may be screened by using multiple aimpoints. Additional information that is necessary for the FDC to determine how many rounds are needed in effect, and the interval of the rounds, includes target length, wind direction, and length of time the smoke is desired. If multiple aimpoints are needed, the location of the second/subsequent aimpoint must be prefaced by announcing "second aimpoint" followed by aimpoint location and "repeat." Example: SECOND AIMPOINT, DIRECTION 1200 MILS, RIGHT 200, ADD 400, REPEAT. A combination of HC and WP is used in the FFE phase.

C.1.8.4 High-Angle Fires. There are several procedures unique to high-angle fires.

1. High-angle fire is fire delivered at elevations greater than the elevation for maximum range to effect a mortar-type trajectory. It is often required when the weapons are firing out of a deep defilade, from within cities, or over high terrain features near friendly troops; or when targets cannot be reached by a low-angle fire because they are located directly behind hill crests, in jungles, or in deep gullies or ravines.

2. When high-angle fire is desired, the observer includes high-angle fire as the type of adjustment in his call for fire, as the method of engagement.

3. The observer procedure for the adjustment of high-angle fire is the same as that for low-angle fire.

4. Ricochet fire is not possible because of the steep angle of fall. Excessive height-of-burst probable error in high-angle fire prohibits the use of time fuze. The steep angle of fall gives the maximum effectiveness in all directions of the spray of a quick fuze shell. This effect with variable time VT fuze is combined with a much lower height of burst than normally is obtained from VT fuze in low-angle fire. Either fuze-quick or fuze VT may be used effectively.

5. The observer must realize that small corrections during adjustment may be unnecessary and time-consuming because of the increased dispersion experienced during high-angle fire.

6. Because of the long time of flight, the FDC, in both the adjustment and fire for effect, announces "shot" when the round or rounds are fired and announces "splash" 5 seconds before the burst or bursts occur. If the mission is observed by an air observer, the FDC announces "shot" and "splash."

C.1.8.5 Cannon Launched Guided Projectile (CLGP) (Copperhead). The copperhead laser-guided projectile may soon be available. The observer and FDC procedures for this special purpose projectile will be included in future revisions to this publication.

C.1.9 Special Techniques for the Aircrew. Adjustment of artillery fire by the aircrew varies only slightly from the techniques used by the ground observer. The call for fire and subsequent corrections are the same for both aircrew and ground observers.

C.1.9.1 Spotting Line. There are several spotting lines that the aircrew could use.

1. A spotting line often used is the gun target line (GTLN). At times, the observer may have to request "ranging rounds" to determine the GT line. If so, the request for ranging rounds is announced in the distribution element of the call for fire. Ranging rounds will be fired 400 meters apart on the GT line. If no direction is announced by the observer, the FDC will make subsequent corrections in relation to the GT line.

2. The aircraft heading indicator will provide accurate direction in most cases. If the aircraft assumes a head-on posture, the reading on the heading indicator would indicate the observer target (OT) line. The OT direction is announced to the nearest 10° and is corrected if the OT direction changes by more than 10°. When making changes or subsequent corrections, ensure the corrections are in relation to the new OT direction. When using the heading indicator, the observer should indicate that the direction is magnetic to avoid confusion.

3. If the aircrew desires to use a "cardinal direction" as the spotting line, they will send the direction in mils to the FDC (e.g., West = Dir 4800).

4. The observer may select a "terrain feature" in the target area to be used as a spotting line. A road, railroad, or series of objects may be used. In any case, the direction of the reference line must be known by the FDC.

C.1.9.2 Target Location. Since an aircraft is constantly moving, the polar plot method is not used by the air observer. If grid coordinates or shift from a known point is used, the procedures are the same as those for the ground observer.

C.1.9.3 Adjustments. Adjustments of subsequent rounds differ for aircrews in that they may use a bracketing method for deviation as well as range.

Estimation of height of burst by an air observer is very difficult. However, if time fire is necessary, the air observer can attempt to distinguish between airbursts and graze bursts to adjust a zero height of burst. If area time fire is required, a zero height must be established, followed by a correction of "up 20" before fire for effect is entered. Normally, time fuze will not be employed if the mission can be accomplished with quick or VT fuze.

Other aids include the use of "at my command" in the method of control element of the call for fire. Additionally, the FDC will send "time of flight" after the message to observer. This will ensure the observer is in a position to observe the rounds and make appropriate corrections.

C.1.9.4 Pop-Up Spotting. Due to the high-threat scenarios, conventional artillery airspot will sometimes be impossible to conduct. Utilizing the pop-up method of spotting will enhance the survivability of the aircrew. The aircrew will announce their intentions to the FDC that they will be adjusting from a "line of known direction" or "cardinal heading." This technique requires the observer to use "at my command" as the method of control announced in the call for fire. Standing off and flying at low level, the aircrew, upon hearing that the artillery is ready, moves to an observation point and while inbound gives the fire command. When the "splash" is received, the aircraft will pop for a visual of the target area and, before descending an adjustment, will be passed to the FDC.

C.2 NAVAL GUNFIRE SUPPORT

Naval gunfire plays a vital role in fire support of landing force operations. The basic task of naval gunfire support units in an amphibious operation is to support the assault of the objective by destroying or neutralizing:

1. Shore installations that oppose the approach of ships and aircraft

2. Defenses that may oppose the landing force

3. Defenses that may oppose the postlanding advance of the landing force.

The threefold mission of naval gunfire is accomplished in three phases. Specific tasks are carried out in each of these phases.

Pre-D-day fires are delivered by the advance force or in supporting operations. The primary mission of the advance force is to destroy enemy batteries and other installations capable of interfering with air, naval, and landing force operations in the objective area. Support is also provided for underwater demolition, reconnaissance, and mine warfare operations. Finally, these fires may include neutralization fires and fires necessary to isolate the objective area. Pre-D-day fires are best characterized as destruction fires.

D-day fires will probably force operations and are planned if there is a requirement not to fire a large volume of fire into the objective area prior to D-day. The main emphasis on D-day, however, is neutralization fires. A requirement to neutralize landing beaches, landing zones, and perhaps approach and retirement lanes may exist. Movement to the beach and off the beach must also be supported. This will be done by providing prearranged close and deep supporting fires. These are scheduled fires delivered to support landing force movement ashore until naval gunfire spotters become established ashore. Close supporting fires are based on the assumed rate of movement of the troops. Deep supporting fires are designed to destroy or neutralize targets away from the immediate vicinity of friendly forces in which known or suspected targets are located, especially indirect fire systems. D-day fires are best characterized as neutralization fires.

The post-H-hour phase of naval gunfire commences as the scheduled fires cease. This occurs when direct support ships begin to receive requests for fire from supported units. During this stage of the operation, naval gunfire responds primarily to landing force requests. This phase terminates either when all gunfire support ships are out of range or the amphibious task force (ATF) is dissolved, whichever occurs first.

C.2.1 Capabilities and Limitations of Naval Gunfire. Naval gunfire has characteristics, some of which are unique, in the role it plays in supporting the landing force. To effectively use naval gunfire support, you must understand the capabilities and limitations of the system.

C.2.1.1 Capabilities

1. Caliber of guns - five- and sixteen-inch guns are available. This will provide an adequate selection of guns of varying capabilities to best accomplish the mission.

2. Ammunition - the different types of projectiles, charges (full and reduced), and fuzes available for each caliber permit selection of the optimum combination. No nuclear round presently exists for the naval gun. Laser-guided projectiles are in various stages of development.

3. Rates of fire - the relatively high rate of fire permits a large volume of fire to be delivered against a target in a short period of time. A large number of rounds on a target in a short period of time has a greater effect than the same number of rounds over a longer time.

4. High initial velocity - the high initial velocity of the projectile makes it suitable for penetrating material targets, particularly those presenting a vertical face on the gun-target line.

5. Flat trajectory - the relatively flat trajectory of the naval projectile increases accuracy and effectiveness in the attack of targets presenting a face vertical to the gun-target level.

6. Deflection pattern - the normal deflection pattern is very narrow. This pattern enables close supporting fires to be delivered to the front lines provided the gun-target line is parallel to the front lines. The pattern also permits effective coverage of targets such as roads, runways, etc., when the gun-target line coincides with their long axis. A narrow deflection pattern is a characteristic of all "gun" systems.

7. Fire control equipment - automated fire control permits accurate fire at anchor or underway. Optical and electronic equipments are available to permit direct fire by the ship.

8. Mobility - within the construction imposed by hydrographic conditions, the firing ship can be placed not only to best support the force, but also to permit maneuver to evade shore fire or other enemy attack means.

C.2.1.2 Limitations. In addition to the capabilities, all users of a weapons system must have a working knowledge of its limitations to employ the system with a high degree of effectiveness. Naval gunfire is no exception.

1. Flat trajectory - this characteristic makes delivery of fire on targets in defilade difficult. Opening the gun-target range or the use of reduced charge may diminish this limitation by raising the trajectory, thereby increasing the angle of fall of the shell.

2. Communications - all communications between the ship and the shore are by radio. Because of this single means, NGF communications are susceptible to various interruptions. Also, since the ship and the spotter are constantly moving, communications may be degraded. Alternate radio nets may be required.

3. Fixing ship's position - the difficulty of accurately determining the exact position of the ship under adverse navigating conditions may result in inaccuracies of the initial salvo of indirect fire. The use of the radar beacon or a reference point identifiable by both the ship and spotter will increase the accuracy of fixing the ship's position.

4. Changing gun-target line - when the ship is firing while underway, the gun-target line will change. This may create an unsafe condition when firing in close proximity to the frontlines. This limitation may be offset by restricting the movement of the firing ship.

5. Effect of hydrography - water depth can determine NGF's maximum range inland. Reefs, shoals, mines, etc., may require the ship to take an unfavorable firing position. The officer commanding the ship or ships will make the final determination as to the distance off the beach that the ships will position themselves.

6. Effect of weather and visibility - heavy weather may force the gunfire ships to temporarily leave the objective area. Reduction in visibility has an adverse effect on the acquisition of, and adjustment to, fire onto targets.

7. Range pattern - the range pattern is relatively long. It may be as much as four times the deflection pattern. When firing perpendicular to the frontlines, an unsafe condition may result. Through mobility, this may be turned to an advantage when attacking long and narrow targets along the gun-target line.

8. Magazine capacity - ammunition capacity is limited. In addition, a reserve for the ship's defense must be retained. This

limitation is partially offset by providing ammunition replenishment in the AOA.

As you can see, certain capabilities in some circumstances become limitations and vice-versa. The spotter with a little forethought should be able to take maximum advantage of his naval gunfire support.

C.2.2 Naval Gunfire Support Missions. NGF support ships are assigned one of two support missions: direct or general support.

1. Direct support - when a ship is assigned the mission of direct support, she will fire into her zone of fire, which corresponds to the zone of action of the supported unit. In naval gunfire, the mission of direct support connotes a destroyer firing in support of a committed infantry battalion. As the number of gun cruisers diminishes, destroyers will also be assigned the mission of general support. Further, helicopterborne units heretofore supported by cruisers because of range requirements will now have to be supported by destroyers (probably longer range 5"/54).

2. General Support - in naval gunfire, the mission of general support connotes a ship in support of a unit of regimental size or larger (not anticipated being held in reserve), division, or higher headquarters. The zone of fire of general support ships should be within the boundaries of the supported unit. Remember that destroyers may well be assigned the mission of general support if the situation and availability of ships so dictate. Battleships are appropriate for assignment to general support.

There are some fundamental differences between the use of words "direct" and "general support" as they relate to artillery and naval gunfire. Direct support in artillery connotes an artillery battalion in support of an infantry regiment. Direct support in naval gunfire implies a ship in support of an infantry battalion. In artillery, general support connotes an artillery unit in support of a division or the landing force as a whole. In naval gunfire, general support connotes a ship in support of a ground combat element (regiment or division).

C.2.3 Landing Force Organization for Naval Gunfire Support. At each level of the landing force down to the committed infantry battalion, there are naval gunfire personnel assigned. (See Figure C-6.)

C.2.3.1 Naval Gunfire Section Landing Force Headquarters. The exact composition of the naval gunfire section of the landing force headquarters depends on the requirements of the landing force.

C.2.3.2 Naval Gunfire Section, Ground Combat Element, MAGTF. The composition of this section will depend upon the size of the ground combat element of the MAGTF.

C.2.3.3 Naval Gunfire Section, Marine Division. At division level, the NGF section is headed by a lieutenant colonel, and he is assisted by a Navy lieutenant commander and enlisted marines who provide operational and communications assistance. The section keeps the commander advised of NGF matters, coordinates NGF in the division FSCC, employs the radar beacons, and prepares the division NGF support plan.

C.2.3.4 Naval Gunfire Officer, Artillery Regimental Headquarters. Within the artillery regimental headquarters battery a Navy lieutenant commander serves as the naval gunfire officer. He coordinates the training of the shore fire control parties in garrison, and he can provide assistance to the division NGF section in operational planning, manning in the FSCC, or serving as the NGF officer in the alternate command post.

C.2.3.5 Regimental and Battalion Naval Gunfire Teams. At infantry regimental and battalion levels, the naval gunfire personnel are provided by the direct support artillery battalion. Each battalion of the artillery

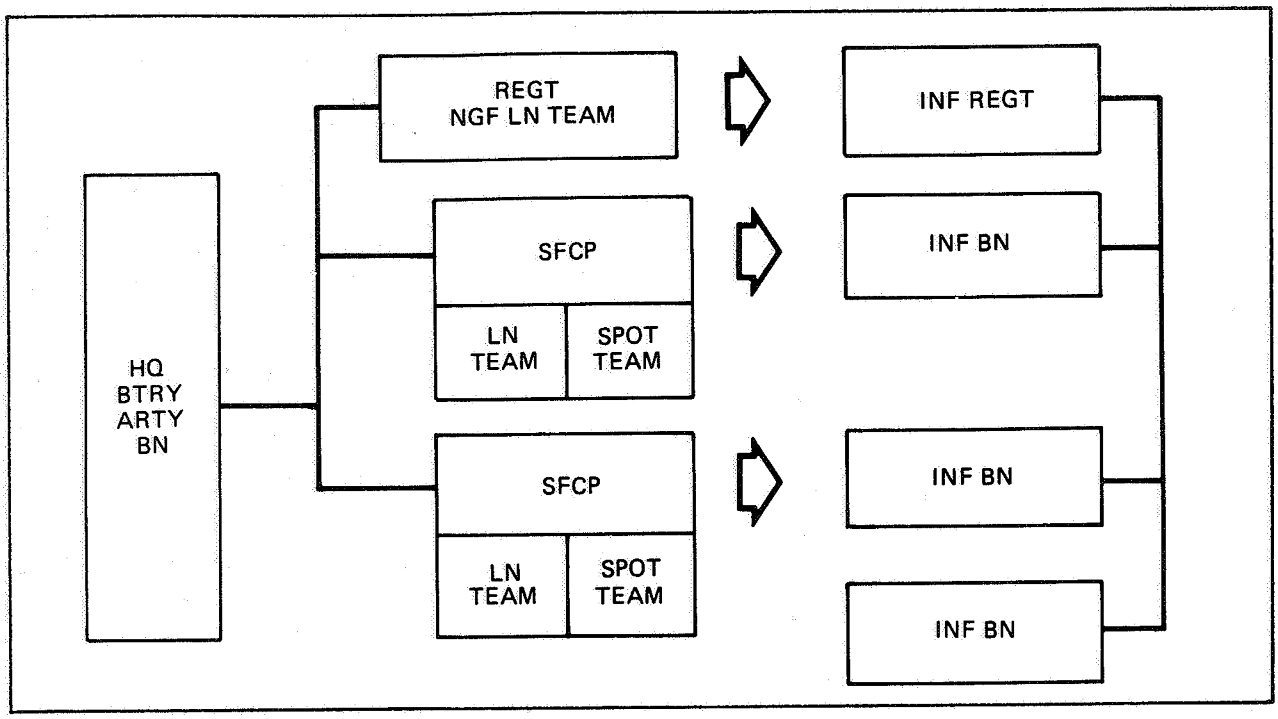


Figure C-6. NGF Personnel for an Infantry Regiment (Assignment as Directed by CO Infantry Regiment)

regiment has a regimental naval gunfire liaison team and two shore fire control parties (SFCPs) in its headquarters battery.

The regimental NGF liaison team is headed by a Navy lieutenant (NGF liaison officer) who has six enlisted marine assistants. This team operates at the infantry regimental FSCC and advises the regimental commander on gunfire matters. Further, the team coordinates the firing of gunfire ship(s) in general support of the regiment. The NGF liaison officer supervises the operations of the two shore fire control parties operating with the battalions.

The SFCP is comprised of two teams. The first is the NGF liaison team, consisting of one Navy lieutenant (j.g.), the NGF liaison officer, and six enlisted marines. One of the enlisted men serves as NGF chief while the rest are communicators. This team is assigned to the infantry battalion and utilized as special staff representative in naval gunfire matters for the infantry battalion commander. This team is under the staff cognizance of the infantry battalion, S-3.

The second team of the SFCP is the NGF spot team. The spot team is headed by a marine lieutenant who is assisted by six enlisted marines (an NGF chief, shore-fire control partymen, and communicators). This team requests and adjusts gunfire for the battalion, either from a battalion observation post or company observation post, the battalion commander deciding with which company the team will operate. For short periods of time, the spot team could be split into two sections to provide an additional spot capability for the battalion. If required, artillery forward observers may function as NGF spotters.

C.2.4 Naval Gunfire Communications. Communication annexes to the amphibious task force, advance force, and landing force operation orders will show the call signs, frequencies, code names, instructions concerning use of voice radio security devices, and other special instructions pertaining to the radio nets to be used.

Amphibious task force (ATF) naval gunfire support nets most commonly used may be found in NWP 22-2. There are five landing force naval gunfire communications nets used when one division is employed.

The division naval gunfire support net is guarded by and provides radio communication among the division naval gunfire officer (NGFO), naval gunfire liaison officers (NGFLOs) of supported regiments, and ships in general support of the regiments and division. It is used for day-to-day NGF support planning. It is also used by the regiments to request NGF air spotters, additional NGF support, and by the regiments and division to assign missions to general support ships.

The division radar beacon net provides radio communications between the division naval gunfire officer and each radar beacon team.

The naval gunfire ground spot net provides communications between the spot team and the direct support ship. The NGFO at the battalion monitors and is normally in net control. One frequency is allocated to each infantry battalion assigned a direct support ship. If a general support ship is assigned a mission in support of the infantry battalion, it will enter the naval gunfire ground spot net of that unit for that mission.

The naval gunfire air spot net is used when missions are spotted from the air. The aerial observer talks directly to the direct or general support ship. When required, the NGFO is at battalion and regiment, and the NGFO, as well as the spot team, may enter this net.

The shore fire control party local net provides a direct link between the battalion NGFO and his spot team. This net is primarily used for administrative purposes. If it becomes necessary, the spot team may send missions over this net to the NGFO who will pass the request to the ship on the NGF ground spot net which he monitors in the battalion FSCC.

The ship air spot reporting in and out net is used by the CATF for controlling the assignment and operations of naval spotting aircraft. All such aircraft will report in and out of it and are briefed and assigned to support ships and shore fire control parties over it.

C.2.5 Naval Guns and Ammunition. Ships in the active fleet are currently armed with a variety of guns, all of which are mission oriented. The gunfire support ships (or combatants) are armed with guns ranging from 3"/50 up through the 16"/47 calibers.

The 3"/50 is primarily an AAW weapon and is not suitable in a gunfire support role due to limited range and shell size. All computations used in targeting naval gunfire are based on the effectivness of the 5"/38. The 5"/54 with a larger shell, greater range, and higher rate of fire is replacing the 5"/38. The 6"/47 is found only on older cruisers. The 6"/47 guns have no significant air defense capability and are currently not in the active inventory.

In discussing naval guns, the terms 5"/38 and 5"/54 refer to the diameter of the bore and the length of the tube in calibers. For example, 5" means the bore has a diameter of 5 inches and 38 means that the tube is 38 calibers long or 38 X 5 inches = 190 inches long (one caliber = one bore diameter). The range capability of a gun is determined, to a great extent, by the tube length.

C.2.5.1 Characteristics of Naval Guns and Ammunition. Figure C-7 presents the characteristics of all current types of naval guns, including maximum and effective ranges, and projectiles available. The number and type of shorefire guns mounted on various types of ships are given in Figure C-8. Figure C-9 provides guidelines for selection of appropriate projectiles and fuzes for various targets.

The large range errors inherent in low trajectory fire make a careful study of the terrain essential. This is especially true of missions fired close to friendly lines. At average ranges, the following minimum safety distances from troops should be observed (data in yards):

Cal.	Parallel to Front Lines	Not Parallel to Front Lines	Target Unobserved
5"	200	350	750
6"	250	450	1,000
8"	250	500	1,000

Note

The minimum safety distance varies with range as shown in the following examples:

Range	Min Safe Distance
10,000	1,950
20,000	2,050
30,000	2,300

C.2.5.2 Naval Gunfire Support Request. Though different radio nets are used, the sequence of obtaining naval gunfire support, as depicted in Figure C-10, is similar to that used for artillery. Clearance is based on the consent of the Naval Gunfire Liaison Officer, indicated by silence. Since the elements of a naval gunfire call for fire are similar to those for artillery, the example given in Figure C-11 illustrates the minor differences that do exist.

C.2.5.2.1 Special Instructions for Timed Fire. When spotting timed fire for height of burst, the following terms are used:

air. All rounds burst in the air.

graze. All rounds burst on impact and not as the result of the mechanical time fuze functioning.

mixed. Indicates that a salvo contains an equal number of air and graze burst.

mixed air (graze). A preponderance of bursts are air (graze).

graze above. Indicates that an impact burst has occurred above target level when firing on irregular terrain.

Corrections are made as shown in Figure C-12.

C.2.5.2.2 Special Instructions for Coordinated Illumination. Figure C-13 is an example illustrating the proper procedures for a coordinated illumination mission. Conserve illumination shells whenever possible, since ships have limited supplies of this type of ammunition.

C.2.6 Naval Gunfire Support Ships. The data contained in the following paragraphs include selected characteristics concerning representative classes of various types of ships. Characteristics of individual ships within a class sometimes vary considerably. Detailed information about a particular ship or ships may be found in NWP 11-1: Missions and Characteristics of U.S. Navy Combatant Ships (U). The publication, Armament of Naval Vessels of the United States (1971 issue), contains a statement of installed and ultimate armament of major ordnance for all U.S. Navy vessels regardless of their fleet status. The preceding two publications are classified CONFIDENTIAL. A fairly comprehensive report of ships' characteristics can be found in JANE'S Fighting Ships.

C.2.6.1 Ship Characteristics. The size and physical dimensions of a naval gunfire support ship directly affect its ability to maneuver. They also determine its ammunition stowage capacity. The draft of the ship is a consideration in how close to the shoreline it may be positioned. The nature of the ship's fire control system determines the number of indirect fire missions which can be conducted simultaneously.

Ships assigned to naval gunfire support are usually cruisers or destroyers. To properly employ a support ship, the planner must know not only the class of ship involved, but also the amount of ammunition available for the supported unit. To determine ammunition availability, the planner should establish liaison with the commanding officer of the supporting ship. If liaison is not possible, the planner may consult NWP 11-1 to determine accurate ammunition figures.

C.2.6.2 Ship Descriptions. There are three distinct types of ships in the Navy today which possess a naval gunfire capability:

The first of these is the modernized *New Jersey* class battleship. The modernization resulted in the addition of cruise missiles and point defense systems and an ECM package.

The second type of naval gunfire-capable cruisers in the fleet is the redesigned DLGs (now CGs) and DLNGs (now CGNs). These ships are large guided missile destroyers and therefore have much the same characteristics as the destroyer types discussed in the following paragraph.

The destroyer-type family, along with related types such as the frigates (FFs and FFGs), and the aforementioned redesignated CGs and CGNs are the most numerous combatants in the Navy. These ships are armed with either the older 5"/38 gun or a version of the newer 5"/54 gun. The number of guns a destroyer carries varies with its type and class. Regardless of the quantity of guns a destroyer-type ship carries, it can fire only one indirect fire mission at a time due to its limited fire control equipment. The destroyers and the other related types are normally assigned a direct support mission of a committed infantry battalion. Before assigning a ship a direct support mission, however, the planner should ascertain the number of gunfire-capable guns aboard the ship. Those ships that possess only one gun cannot fire a simultaneous, coordinated-illumination, high-explosive mission.

GUNS	ROUND	MAX. RANGE (YDS)[1]	EFFECTIVE RANGE (YDS)	BURSTING RADIUS (YDS)	RATE OF FIRE (RPMG)
FULL CHARGE					
16"/50	HC AP	42,315	41,000	180	2
8"/55	HC	30,400	22,000	90	3
6"/47	AP	26,200	18,000	NA	10
	HC	24,000	18,000	60	10
5"/54	HC	25,400	18,000	40	35
5"/38	AAC	17,300	15,000	40	15
	HC	17,400	15,000	40	15
3"/50	AAC	14,000	11,000	5	50
REDUCED CHARGE					
8"/55	HC	23,400	22,500	90	
6"/47	HC	19,000	19,200	60	
	AP	20,100	19,400		
5"/54	AAC	13,500	11,300		
5"/38	AAC	8,900	7,500	40	
ROCKET ASSISTED PROJECTILE[2]					
5"/38[3]	HC	26,000	34,200	20	
5"/54[4]	HC	30,000	28,000		

Notes:

1. The maximum horizontal range listed is computed using standard conditions and new barrels. Day to day maximum range will vary considerably depending upon bore wear and atmospheric conditions.
2. RAP ammunition is designed for use against light structures and personnel and has limited destructive capability due to only 3.3 pounds burster charge. Effectiveness is achieved through increased fragmentation from cast projectile body. Effective utilization of RAP ammunition requires that it be fired with fuze set in CVT mode. However, if tactics dictate use of PD functions, fuzes should be set for a time greater than the actual time of flight vice on PD. Setting PD on CVT fuzes does not assure VT function is de-energized. Accuracy of RAP ammunition is one percent of range or 3 mils.
3. Minimum range is 18,000 yards.
4. Minimum range is 20,000 yards.

Figure C-7. Naval Guns and Ammunition

CLASS	GUNS TYPE	NO.	AMMUNITION CAPACITY[1]
BB—Battleship			
Iowa	16"/50	9	1,200
	5"/38	12	6,000
CG—Guided Missile Cruiser			
CG-26 Belknap	5"/54	1	600
CG-47 Ticonderoga	5"/54	2	1,200
CGN—Guided Missile Cruiser (Nuclear)			
CGN-9 Long Beach	5"/38	2	500
CGN-36 California	5"/54	2	1,200
DD—Destroyer			
DD-963 Spruance	5"/54	3	1,800
DD-993 Kidd	5"/54	2	1,200
	5"/38	1	1,200
FF—Frigate			
FFG-1052 Knox	5"/54	1	600
FFG—Guided Missile Frigate			
FFG-1 Brooks	5"/38	1	300

1. Ammunition allowance figures are approximate and will vary from ship to ship in a given class.

Figure C-8. Naval Gunfire Support Ships

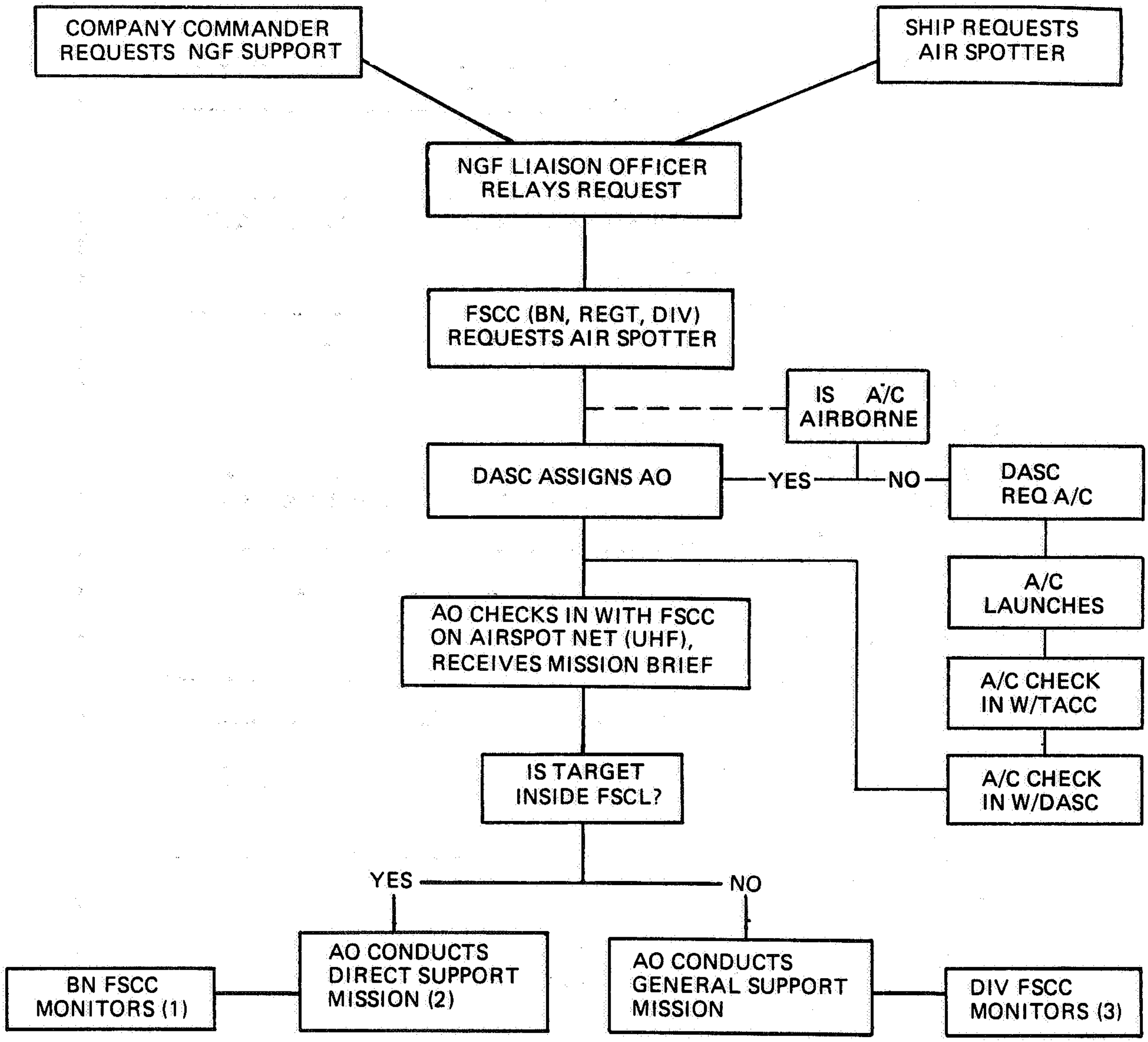
TARGET	SHIP'S GUNS	RECOMMENDED PROJECTILES AND FUZES
Heavy Concrete Fortifications	16 Inch	AP
	8 Inch & 6 Inch	AP
	5 Inch & Smaller	Not Recommended
Light Concrete Or Log And Earth Fortifications, Strong Masonry Buildings	16 Inch	HC (PDF)
	8 Inch	HC (Nose Plug)
	6 Inch	AP Note 1
	5 Inch	COM Note 1
Dispersed Targets In Open, Such As Parked Aircraft, Vehicles, Personnel, Light Frame Buildings.	16 Inch	HC PDF & Nose Plug
	8 Inch & Smaller	HC (PDF), AAC, Or VT Note 2
	5 Inch	HC (VTF, MTF Or PDF)
Large Targets Of Light Construction Such As Oil Tanks, Hangars, Factory Buildings.	16 Inch	HC (PDF & Nose Plug)
	8 Inch To 5 Inch	HC (PDF At Short Range, Nose Plug At Long Range)
Runways And Roads, Paved Or Unpaved.	ALL	HC (Nose Plug)

Notes:

1. Projectile not particularly effective against this target but is more effective than a non-delay fuzed projectile.

2. MTF should be set to obtain a low-level air burst. If height of burst can be accurately controlled, MTF will be preferable to PDF. At short ranges MTF is preferable to VT due to erratic functioning of VT at low angle of fall, VT fuzes employed in long-range bombardment must be NSD.

Figure C-9. Projectile-Fuze Selection for Shore Targets


COMPANY COMMANDER REQUESTS NGF SUPPORT
SHIP REQUESTS AIR SPOTTER
NGF LIAISON OFFICER RELAYS REQUEST
FSCC (BN, REGT, DIV) REQUESTS AIR SPOTTER
IS A/C AIRBORNE
DASC ASSIGNS AO
YES
NO
DASC REQ A/C
A/C LAUNCHES
A/C CHECK IN W/TACC
A/C CHECK IN W/DASC
AO CHECKS IN WITH FSCC ON AIRSPOT NET (UHF), RECEIVES MISSION BRIEF
IS TARGET INSIDE FSCL?
YES
NO
BN FSCC MONITORS (1)
AO CONDUCTS DIRECT SUPPORT MISSION (2)
AO CONDUCTS GENERAL SUPPORT MISSION
DIV FSCC MONITORS (3)

Notes:

1. Although silence indicates consent, clearance shall be confirmed with controlling NGF Liaison Officer (Bn FSCC) prior to firing direct support missions whenever reliability of communications is questionable.
2. To obtain current target and friendly information during the conduct of the mission, the AO may contact the NGF spotter (usually with the company commander) and the battalion FSCC on the Shore-fire control party (local) net.
3. Silence indicates consent to fire the mission.

Figure C-10. Naval Gunfire Airspot Mission Flow Chart

NAVAL GUNFIRE CALL FOR FIRE

1. OBSERVER IDENTIFICATION: ____________________

2. WARNING ORDER: FIRE MISSION TARGET NO. ____________________

—OVER—

3. TARGET LOCATION: ____________________

(GRID COORDINATES, POLAR COORDINATES, SHIFT)

a. ALTITUDE (METERS ONLY)

b. DIRECTION (SPECIFY) ____________________

(DEGREES, MILS, MAG, TRUE, GRIDS)

4. TARGET DESCRIPTION:

5. METHOD OF ENGAGEMENT:

a. DANGER CLOSE (DIRECTION/DISTANCE) ____________________

(OMIT IF MORE THAN 750M FOR 5" AND 1,000 FOR 6" AND LARGER)

b. PROJECTILE (OMIT IF HE) ____________________

c. FUZE (OMIT IF Q) ____________________

6. METHOD OF FIRE AND CONTROL:

a. NUMBER OF GUNS (OMIT IF ONE DESIRED) ____________________

b. ARMAMENT (OMIT IF MAIN DESIRED) ____________________

c. CONTROL ____________________

(SPOTTER ADJUST, SHIP ADJUST, AMC, FFE, CANNOT OBSERVE)

—OVER—

EXAMPLE:

1. B1 THIS IS H8C17.
2. FIRE MISSION. TARGET NUMBER AG1053, OVER.
3. GRID 125647, ALTITUDE 210M, DIRECTION 300 DEGREES GRID;
4. 20 TROOPS IN OPEN;
5. DANGER CLOSE SE 500M, TIME IN EFFECT;
6. SPOTTER ADJUST, OVER.

NOTES:

1. The target number is determined and announced by the air spotter for targets of opportunity. For preplanned targets, the number comes from the target list of the fire plan.

2. Danger Close signifies a target 0-1,000 meters from friendlies. This mandatory term is followed by a cardinal or inter-cardinal direction and distance in yards from the target to friendly troops. As in Artillery Air Spot, the "Creeping" method of adjustment will be utilized in the NGF danger close mission.

Figure C-11. Naval Gunfire Call-for-Fire

	SPOT	CORRECTION	EXPLANATION
1.	Air	"Down"	An appropriate amount to result in a 20-yard height of burst. (5", 6", and 8")
2.	Graze	"Up 40"	If short of target, range is doubtful and no range change can be made.
3.	Mixed (or previous Air Burst in Mission)	"Up 20"	Yards are always understood when making corrections.
4.	Mixed Air	No Height Correction	Height of burst assumed to be correct.

Figure C-12. Corrections for Timed Fire

ELEMENT	EXAMPLE
1. Spotter ID	"FAVOR THIS IS CHIPPEWA ONE-NINER"
2. Warning Order	"FIRE MISSION, TARGET NUMBER ONE-ONE NINER, OVER."

-------------------BREAK FOR READBACK BY SHIP-------------------

3. Location	"GRID FOUR-FOUR-FOUR-SIX-SIX-SIX, ALTITUDE TWO-ZERO YARDS, BEARING GUN TARGET NINE,"
4. Description	"FOUR TRUCK CONVOY TRAVELING SOUTH,"
5. Method of Engagement	
(a) Type Adjustment	"DANGER CLOSE SOUTHWEST FIVE HUNDRED,"
(b) Trajectory	(Not applicable)
(c) Ammunition	"ILLUMINATION,"
6. Method of Fire and Control	
(a) Method of Fire	"ONE GUN"
(b) Method of Control	"PREPARE TO FIRE HIGH EXPLOSIVE AFTER ILLUMINATION ADJUSTMENT, ADJUST FIRE, OVER,"

-------------------BREAK FOR READBACK BY SHIP-------------------

After Illumination Adjustment

1. Spotter May Transmit:	"CONTINUOUS ILLUMINATION, ILLUMINATION CHECK FIRE, HIGH EXPLOSIVE, FUZE QUICK, TWO GUNS, AT MY COMMAND, ADJUST FIRE, OVER."

-------------------BREAK FOR READBACK BY SHIP-------------------

2. After the ship transmits – "HIGH EXPLOSIVE READY" report to spotter, the spotter would follow with: "ILLUMINATION, CANCEL CHECK FIRE, OVER."

3. As soon as the target is properly lighted, the spotter would transmit (for example): "HIGH EXPLOSIVE, FIRE, CANCEL AT MY COMMAND, OVER."

4. Subsequently, the ship would continue firing illumination, while a normal adjustment and fire for effect mission would be conducted for the high explosive shells. Each correction/command must be prefaced by the shell to which it is to be applied.

5. The spotters command of "END OF MISSION," would terminate the illumination firing.

Figure C-13. Typical Naval Gunfire Coordinated Illumination Mission

APPENDIX D

Conventional Weapons Fragmentation Patterns

D.1 GENERAL

This appendix contains illustrations with physical characteristics and fragmentation patterns for the most widely used conventional weapons which are delivered by fixed-wing attack aircraft.

D.2 MAXIMUM FRAGMENTATION ENVELOPES

Maximum fragment envelopes for various weapons are shown in Figures D-1 through D-10. Each plot shows the growth in pattern size after weapon detonation. In order to establish safe clearance limits for participation in simultaneous operations with other aircraft, helicopter commanders must consider the effects of fragments for their own weapons as well as other participating aircraft. For this reason, fragment envelopes are presented in two separate parts: the first is for helicopters and low-speed support aircraft (e.g., OV-10), while the second applies to high-speed attack aircraft (e.g., A-4, A-7).

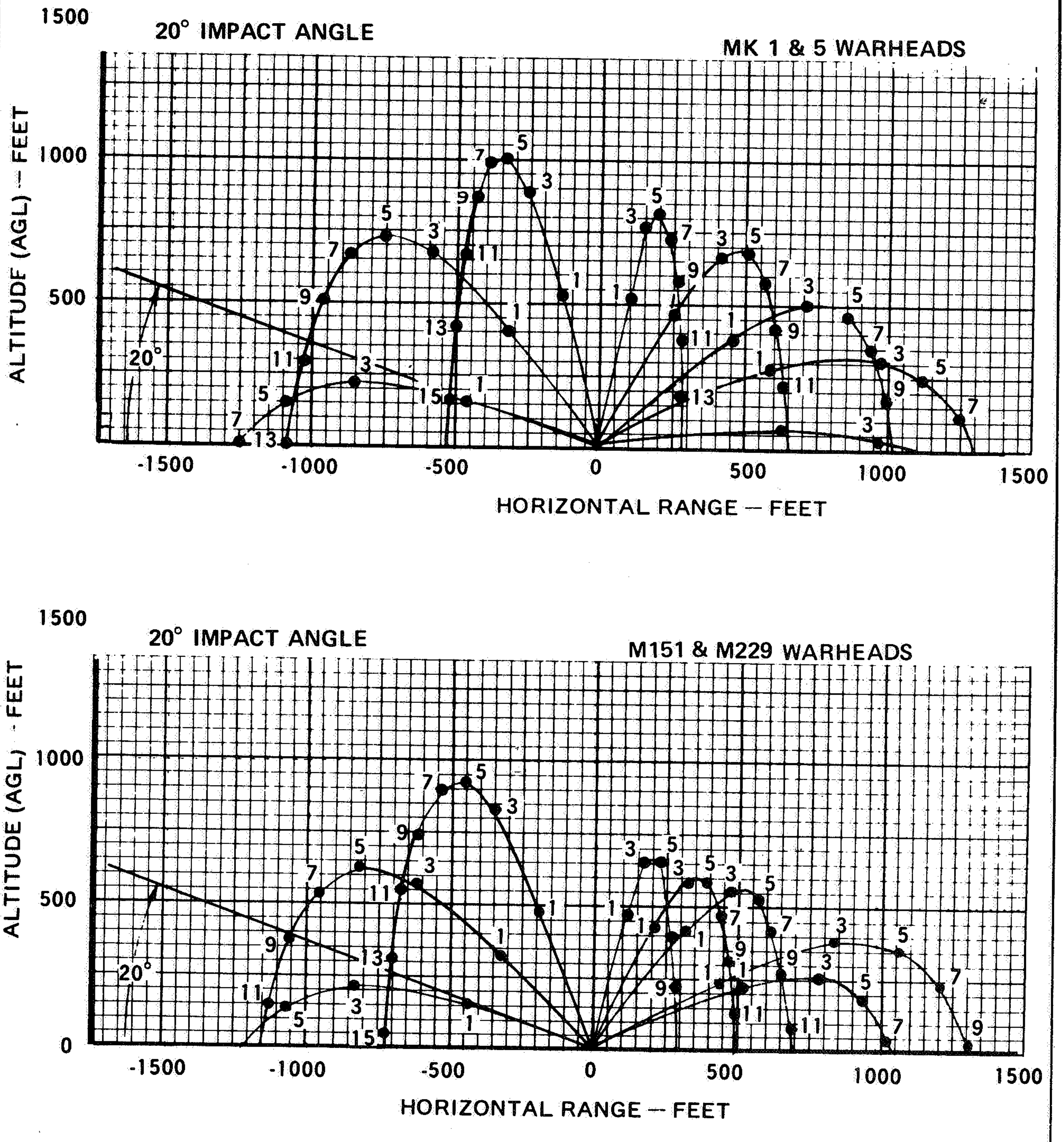
Figure D-1 shows the fragment patterns for 2.75-inch rockets approved for carriage on the AH-1J and AH-1T. Only patterns for 20° impact angle are shown; the 20° envelopes can be used for 10° and 30° impact angles by simply rotating the figure ± 10°. These patterns, in combination with the dive recovery profiles flown by VX-5, were used in establishing minimum safe release altitude. The results were then incorporated into altitude release restrictions, where applicable.

Because of their low-speed, low-altitude capability, helicopters can participate in tactical situations at close range to targets under attack by friendly aircraft. Fragmentation envelopes for weapons carried by high-speed attack aircraft are shown in Figures D-2 through D-12. These data have been taken directly from jet aircraft tactical manuals and are representative of the combat situations expected. They apply to delivery airspeeds in the 350- to 450- KTAS range.

D.2.1 Description. General-purpose, low-drag, Mk-80-series bombs are one of the most widely used weapons in inventory. Mk-80-series bombs may be equipped with conical or retarding fins, depending on the tactical application. Retarding fins, used on the Mk-81, -82, and -83 bombs, allow release in either the retarded or the low-drag configuration.

Their cases are relatively light, and approximately 50 percent of their total weight is explosive. Although not intended for penetration of armor, the case is sufficiently strong to provide good weapon penetration if the bomb is fuzed for the proper functioning delay. When fuzed for instantaneous or VT functioning, they provide good fragmentation effects for use against personnel and light equipment.

GP bombs are equipped for both electrical and mechanical fuzing, have nose and tail fuze wells, and have internal electrical cabling. With mechanically fuzed bombs, nose or tail-well boosters are used. Electric fuzes have their own built-in booster. Structurally, the nose well is the weakest part of the bomb and requires a steel nose plug and support cup (or an inert nose fuze) to prevent weapon breakup if only tail fuzing is used.

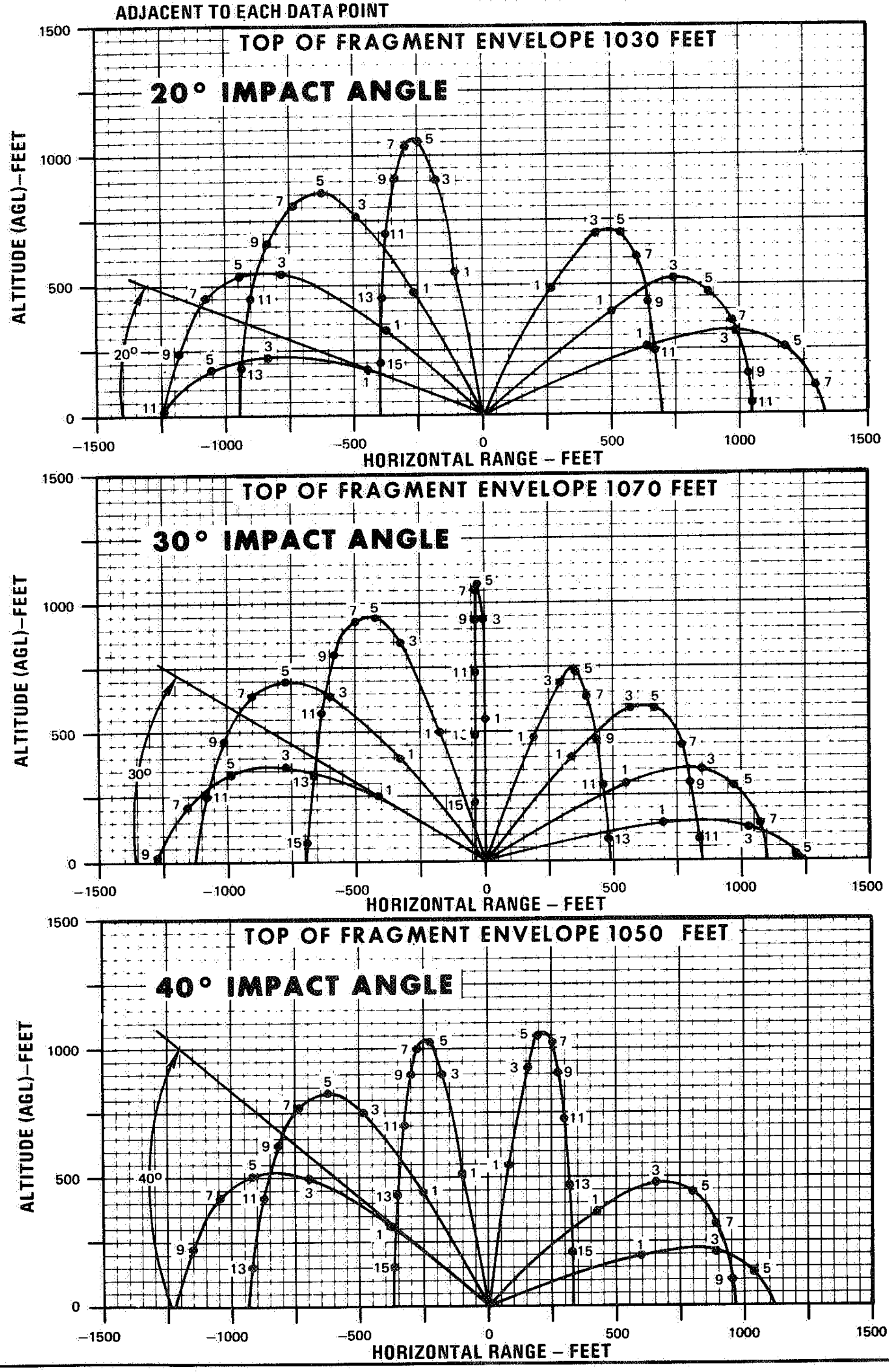


209900-713

Figure D-1. 2.75-Inch FFAR Helicopter Delivery

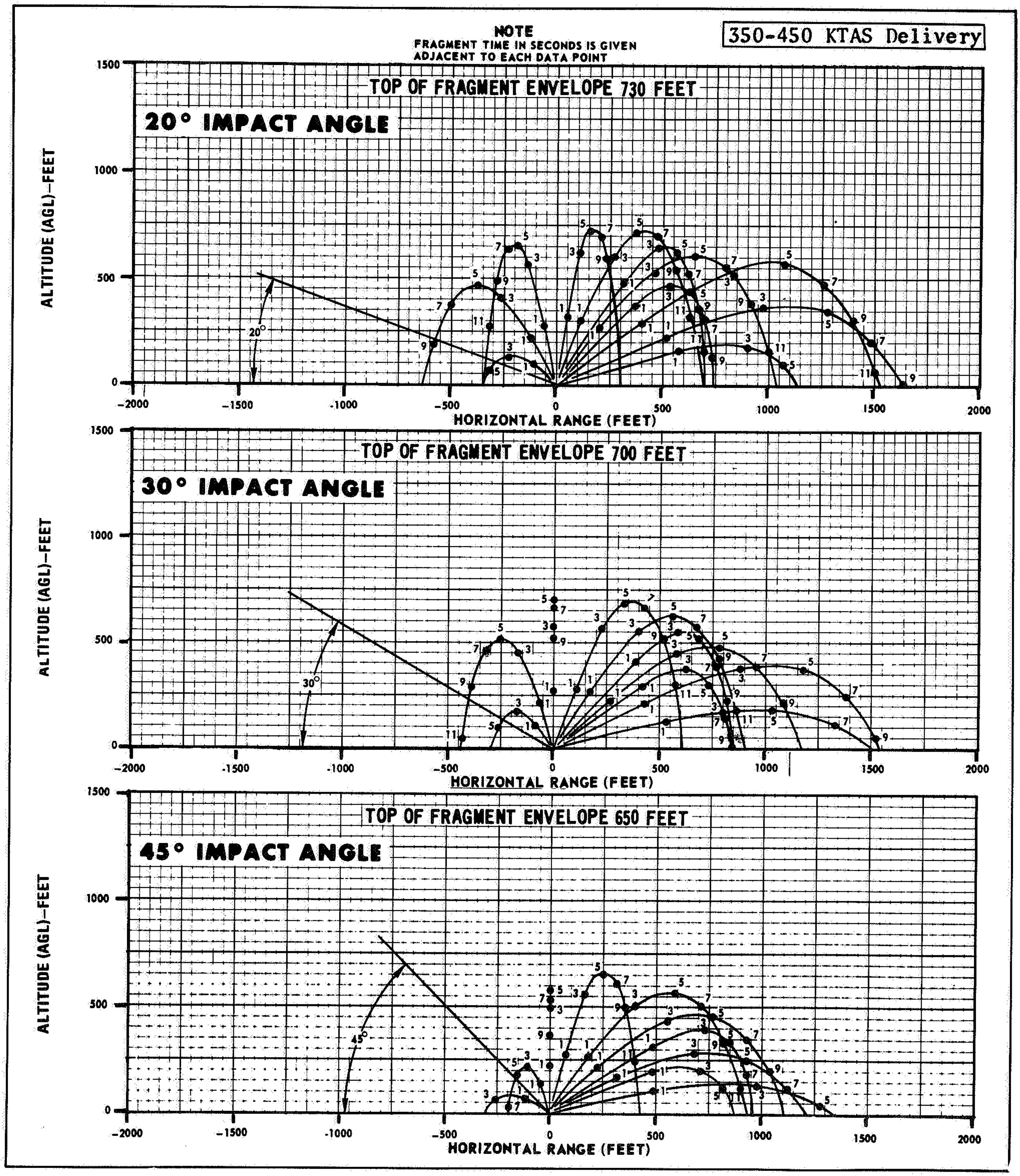
NOTE
FRAGMENT TIME IN SECONDS IS GIVEN
ADJACENT TO EACH DATA POINT

350-450 KTAS Delivery



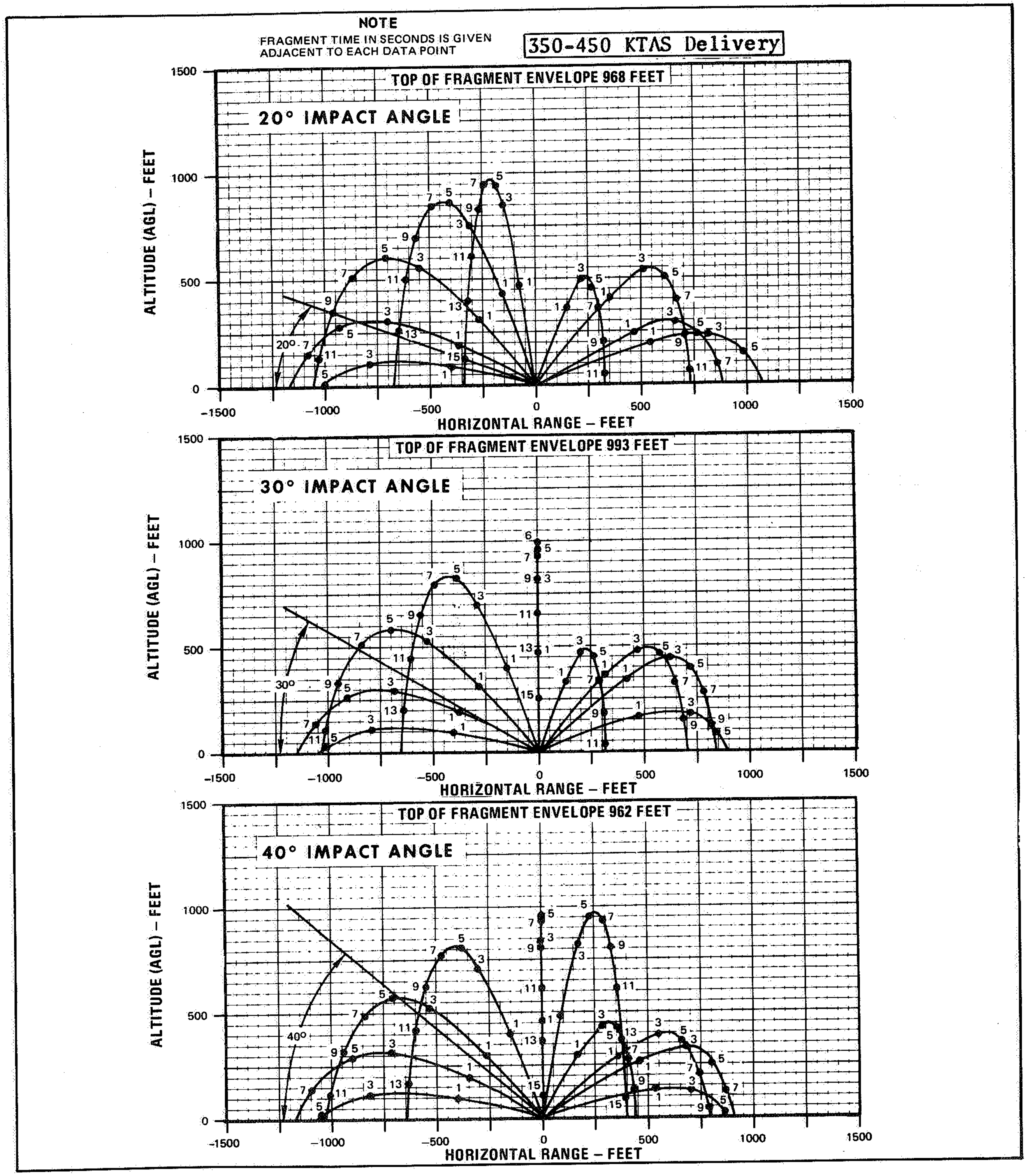
209900-712

Figure D-2. Maximum Fragmentation Envelope 2.75-Inch FFAR With MK 1 Mod 1 Warhead



209900-711

Figure D-3. 2.75-Inch FFAR With M151 Warhead Maximum Fragmentation Envelope



NOTE

FRAGMENT TIME IN SECONDS IS GIVEN ADJACENT TO EACH DATA POINT

350-450 KTAS Delivery

Figure D-4. Maximum Fragmentation Envelope 2.75-Inch FFAR With M229 Warhead

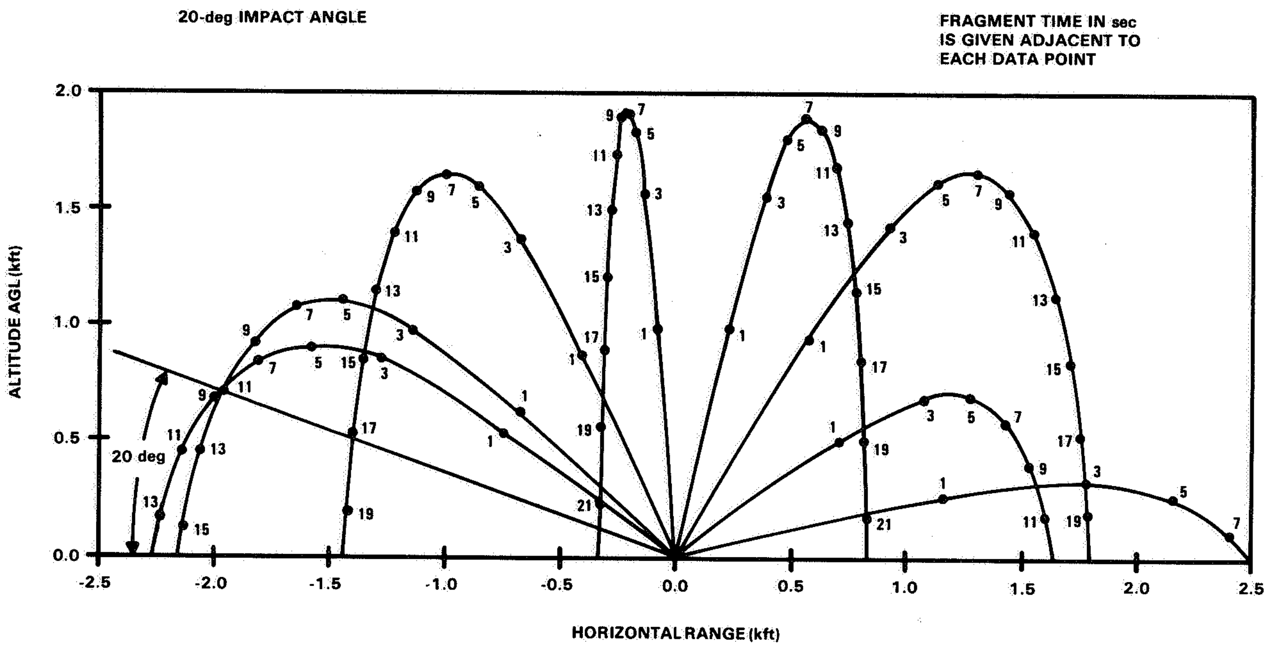


Figure D-5. Maximum Fragment Envelope — 5-Inch FFAR (ZUNI) With Mk-24 Mod 0 Warhead

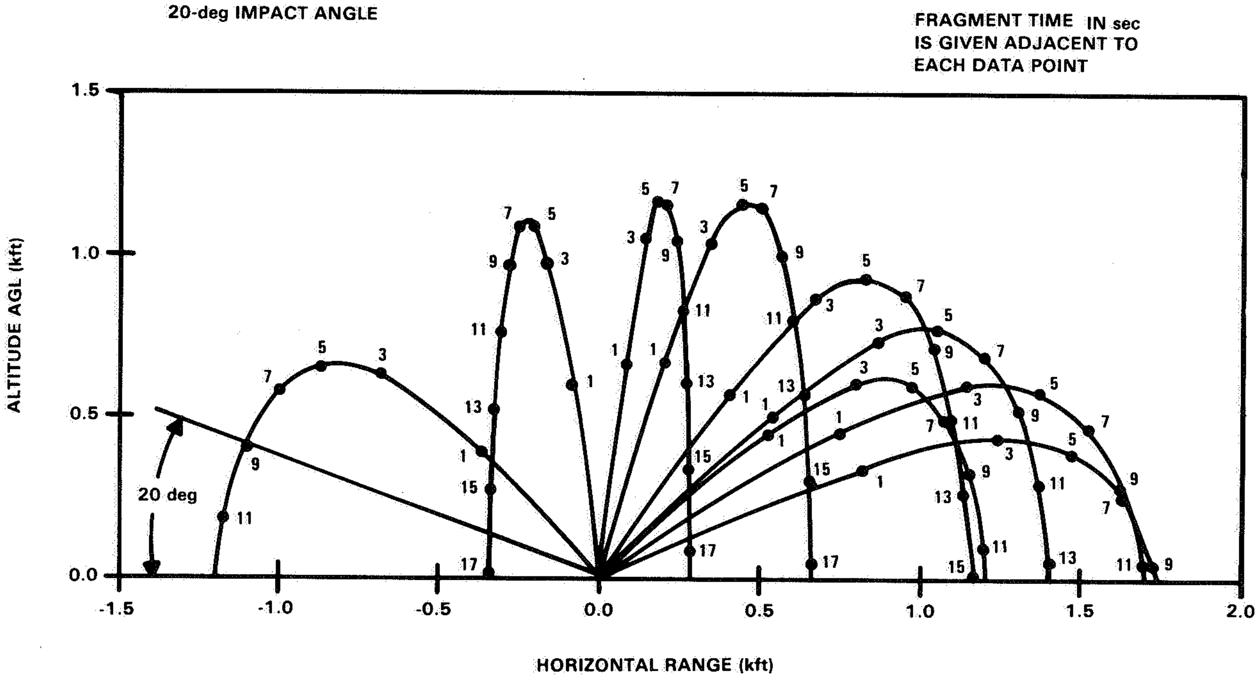


Figure D-6. Maximum Fragment Envelope — 5-Inch FFAR (ZUNI) With Mk-32 Mod 0 Warhead

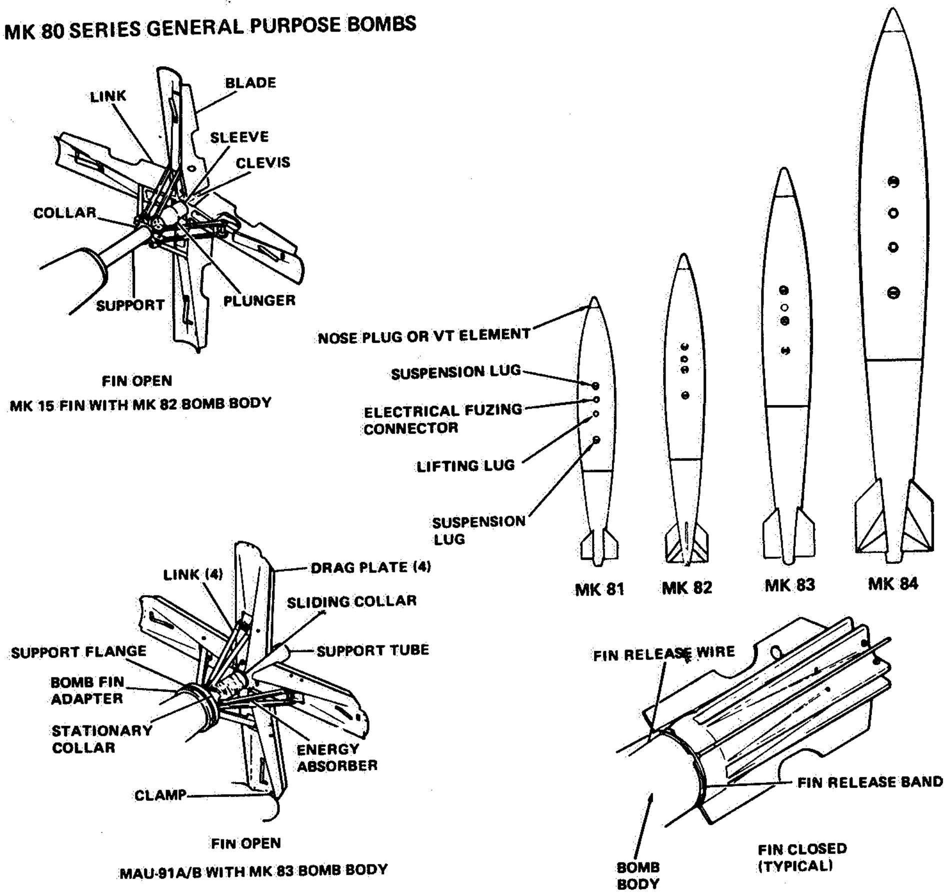


Figure D-5

Characteristics	MK 81	MK 82	MK 83	MK 84
Length of assembled bomb (Inches)				
Conical	74	86	118	151
SNAKEYE	75	89	113	N/A
Explosive weight (Pounds)	100	192	445	995
Diameter (Inches)	9	11	14	18
Suspension (Inches)	14	14	14	30
Total weight (Pounds)				
Conical	260	531	985	1970
SNAKEYE	305	565	1057	N/A
Identifying markings (All)	Olive drab body with yellow bands			

Figure D-7. Mk-80-Series, General-Purpose Bombs

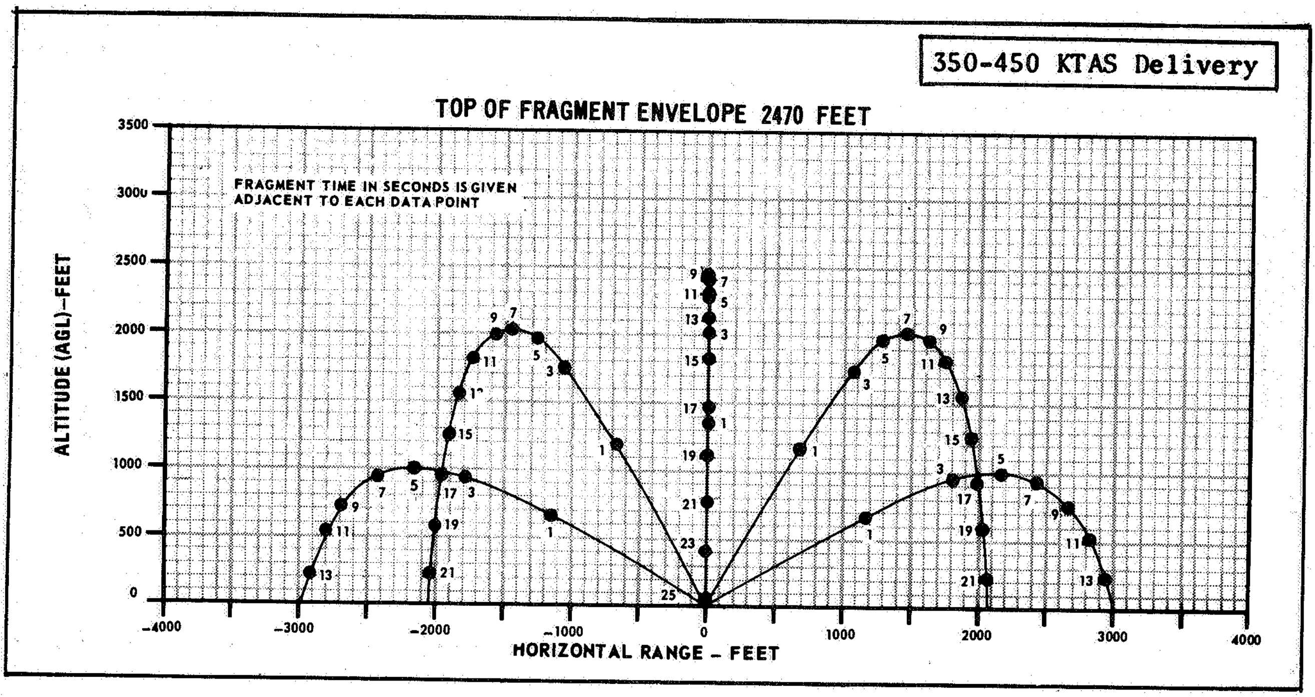


Figure D-8. Mk-81 Bomb Maximum Fragment Envelope

209900-708

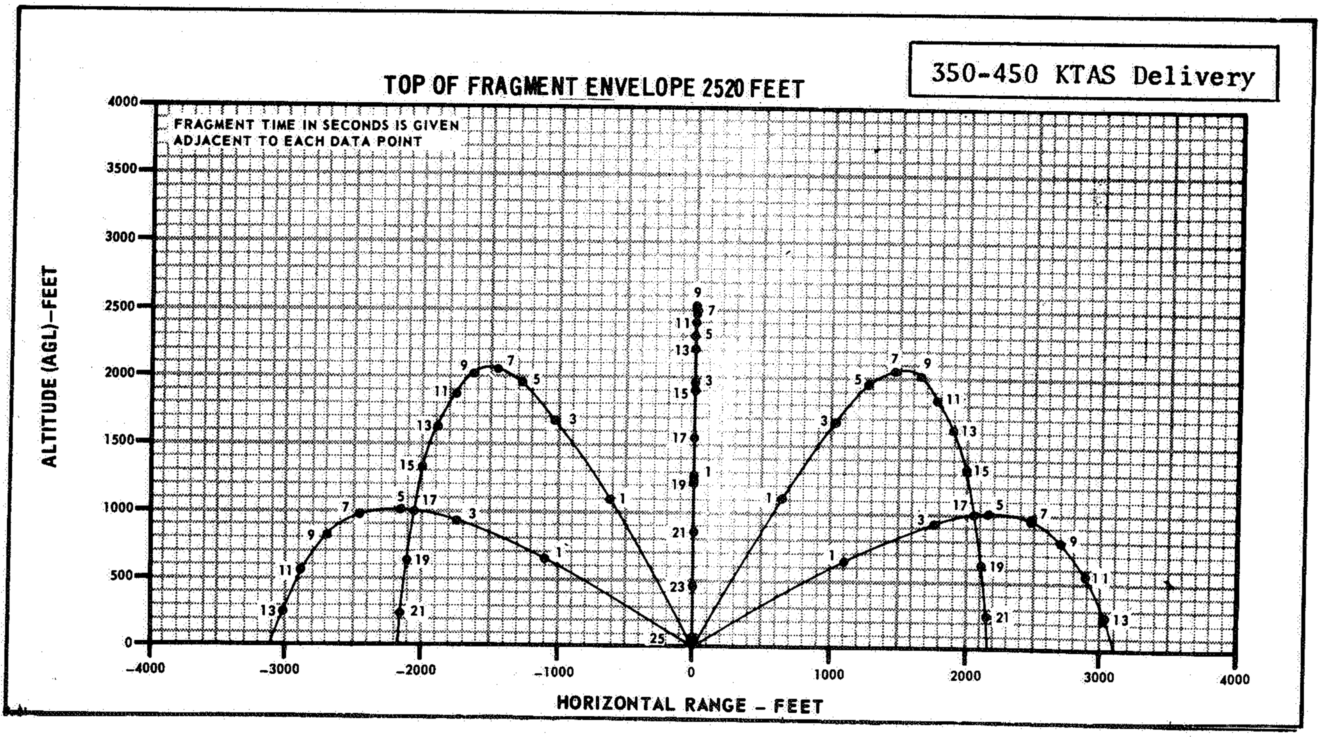
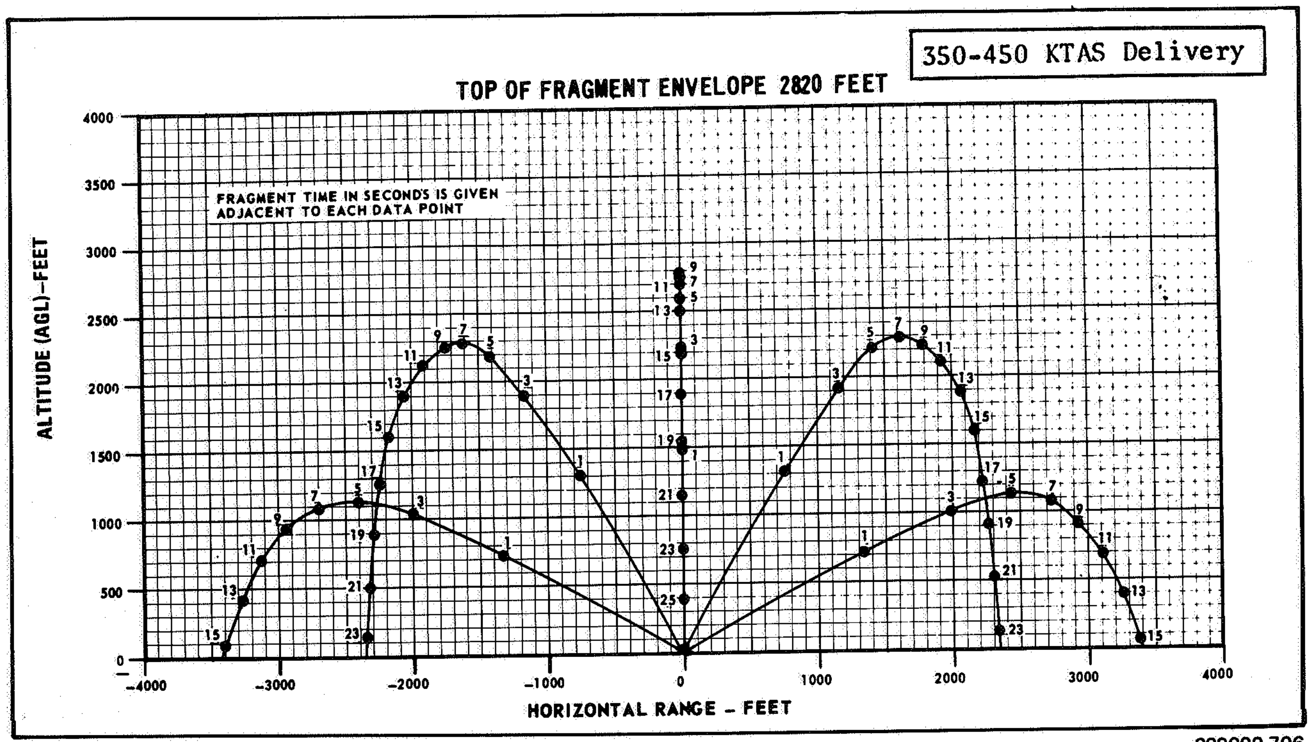


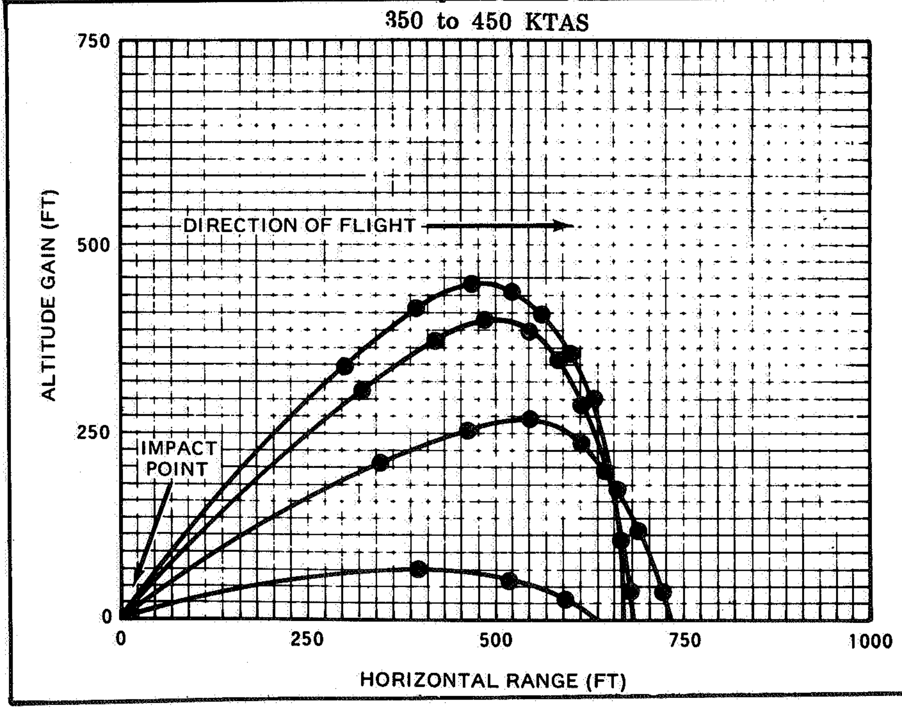
Figure D-9. Mk-82 Maximum Fragmentation Envelope

209900-707



209900-706

Figure D-10. Mk-83 Maximum Fragmentation Envelope



NOTES:

1. Weapon impact angle 10 degrees.
2. Data points are plotted for each second of trajectory time.

209900-705

Figure D-11. 20-mm Ammunition Fragmentation Envelope

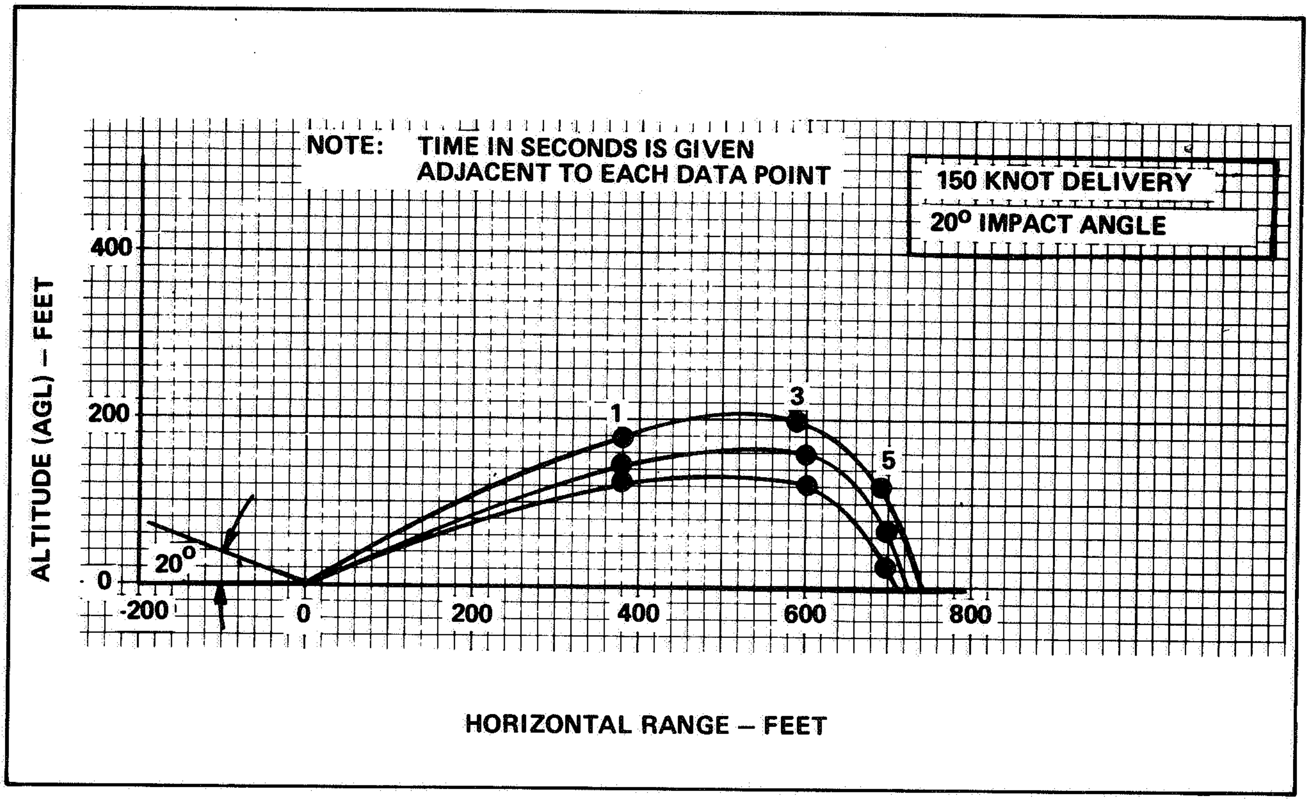


Figure D-12. 20-mm Mk 12 Projectile Maximum Fragmentation Envelope

Recent production GP bombs have a thermal protective coating. Provided thermally protected fuzes are used, this coating provides several minutes additional time before the bombs detonate or deflagrate (go low-order) during a fire.

D.2.2 Conical Fins. Conical fins are compatible with all all Mk-80-series bombs. The fins may be + or x configured, depending on loading requirements. The fins are fitted with an access cover for inspection of tail fuzing and have holes drilled in the 6 and 12 o'clock position for the feed through of the electric fuzing arming wire.

D.2.3 Retarding Fins. Mk-81, -82, and -83 bombs may be fitted with high-drag fins which enable them to be delivered in the retarded or unretarded mode. With the retarding fins, the impact angle is increased. This provides greater weapon effectiveness in low-level delivery. The increased bomb to aircraft separation afforded by the retarding fins permits the use of shorter fuze arming times.

Mk-14 fins are used with Mk-81 bombs, Mk-15 fins with Mk-82s, and MAU-91 fins with the Mk-83s. There are no retarding fins for Mk-84 bomb. The retarding fins are actuated by a fin release wire which is normally attached to the bomb rack solenoid to provide an in-flight option of release modes. Some applications require the use of an additional interlocking arming wire which is connected between fins and the nose fuze to ensure that the nose fuze will not arm unless the fins have been deployed.

Additional information on use and application of GP bombs is found in Chapter 3 and in JMEM.

WARNING

Although a GP bomb can be released safe and will theoretically dud at impact, bombs may go high-order. Therefore, all normal release restrictions (minimum release altitudes, safe separation, etc.) must be observed when jettisoning bombs.

APPENDIX E

Helicopter Day and Night Tactical Formation Flying (STANAG 3627)

E.1 NATO STANDARDIZATION AGREEMENT (STANAG)

A NATO Standardization Agreement (STANAG) is promulgated by the Chairman of the Military Agency for Standardization (MAS) under the authority vested in him by the NATO Military Committee.

No departure may be made from the agreement without consultation with MAS. Nations may propose alterations at any time should they consider that the original has become obsolete or requires improvement. Such proposals should be submitted to MAS, where they are processed in the same manner as the original agreement. (Users of this manual should submit change recommendations in accordance with the introduction.)

Ratifying nations have agreed that national orders, manuals, and instruments implementing a STANAG will include a reference to the STANAG number for purposes of identification.

The following apply:

1. Ratification — the declaration by which a nation formally accepts the content of a STANAG.

2. Implementation — the fulfillment by a nation's forces of their obligations under a STANAG.

Details of the state of ratification and implementation are included.

The paragraphs and figures in this appendix constitute the U.S. Navy implementing instruction for STANAG 3627. References to this material must include the STANAG number.

E.1.1 Object. The aim of this agreement is to establish procedures for helicopter tactical formation flying.

E.1.2 Agreement. Participating nations agree, in accordance with the organization of their respective force, to apply the procedures outlined below to all tactical formation flying of helicopters. It is also agreed that tactical formation flying may not be possible at times in the forward areas of the battlefield. The enemy threat capability will be the major factor in determining the type of formation to be used.

E.2 RESPONSIBILITIES OF COMMANDERS

E.2.1 Helicopter Force/Air Mission Commander. The helicopter force/air mission commander is the controlling helicopter commander. The helicopter force/air mission commander will effect liaison with subordinate supporting helicopter units and supported ground units. He should brief subordinate helicopter units on the following:

1. Number of helicopters required for the mission

2. Types of formations to be used

3. Location of commander

4. Numbering system of helicopters in formation

5. Method of changing formations

6. Use of *free cruise*

7. Angular relationships of helicopters

8. Vertical and horizontal separation

9. Use of aircraft lights

10 Rendezvous and join-up procedures

11. Inadvertent IMC procedures

12. Signal requirements

13. Downed aircraft procedures

14. Status of armed escort helicopters

15. Details of landing zones

16. Formation to and from landing zones

17. Available intelligence concerning en route routes and landing zones

18. Lost communications procedure (if different from SOP)

19. Rules of engagement

20. Refueling and rearming locations

21. Emergency break procedures.

22. Emergency medical facilities to be used.

The helicopter force/air mission commander should brief supported ground units on the following:

1. Formations normally employed by the unit

2. Use of lights by the helicopter unit

3. Probable en route formations

4. Downed aircraft procedures

5. Frequencies and call signs.

E.2.2 Supported Ground Unit Commander. The supported ground unit commander should brief the helicopter unit on the following:

1. Location and details of landing zones

2. Desired formation for pickup and landing of troops and cargo

3. Specific landing points of lead aircraft in landing zone

4. The ground unit commander's location, if airborne

5. Control he will provide for aircraft in the landing zones

6. Location and identification of alternate landing zones

7. Fire support in the preparation of landing in landing zones

8. Safe route into the area, if known

9. Rules of engagement

10. Disposition of friendly troops.

E.3 PROCEDURES

E.3.1 Location of Commander. The helicopter force/air mission commander need not fly as a member of the formation. He may fly above or to the flank of the formation. He should be able to move to any position to best command the aviation unit(s) or to coordinate with supported and supporting units as required. If the helicopter force/air mission commander does not lead the formation, a flight leader should be designated to fly within the formation, normally in the lead aircraft.

E.3.2 Types of Formations. Types of formations are as illustrated in Figures E-1 through E-7.

E.3.3 Numbering of Aircraft. Aircraft within formations are numbered starting with the leader; then progressively left to right or right to left, laterally, through each succeeding lateral space area. These aircraft can be changed easily into other related formations such as a column or trail, right echelon and left echelon, and still maintain their original numbers within the new formation.

E.3.4 Separation. The formation to be flown depends on such factors as enemy situation, nature of the terrain, visibility, proficiency of the aircrews, types of helicopters involved, and the technique of movement employed. The separation between aircraft in the formation is also affected by these factors, but separation is mostly dependent on the degree of flexibility required in airspeed and altitude. Because of the flexibility required, not all formations are suitable for aviation operations conducted in support of the land battle. When flight is conducted at a constant altitude and airspeed, close formation may be flown where the separation between aircraft of the same element is 1-1/2 to 2-1/2 rotor diameters. During conditions where the altitude and airspeed must be varied, a loose formation (3 to 5 rotor diameters) or an extended formation (greater than 5 rotor diameters) may be flown. Never should the minimum separation between the tips of the rotor discs be less than 1-1/2 rotor diameter (Figure E-7).

Aircrews will not always be required to maintain constant separation between aircraft, but may vary their position within the formation when maneuvering about the battlefield (flexible position). It is a maneuver which permits the wingman in a two-ship section to freely maneuver in the zone extending 45° either side and to the rear of the leader. The distance that the wingman trails the leader is dependent on visibility, the terrain, and range of organic weapons. During this maneuver, the wingman must not lose visual contact with the leader or fly at an airspeed which will cause him to overtake the leader. The flexibility of this maneuver enables the wingman to choose his own flightpath in order to avoid obstacles, use terrain to the maximum advantage, or orient firepower toward known or suspect enemy positions.

Supporting helicopter units should be thoroughly briefed by the helicopter force/air mission commander regarding the formation to be flown and the lateral and vertical separation to be flown.

E.3.5 Rendezvous and Join-Up. The helicopter force/air mission commander should provide rendezvous and join-up procedures to supporting helicopter units. If necessary, briefings are to be conducted so that all personnel involved are thoroughly familiar with the procedures.

E.3.6 Recovery of Downed Aircraft. Procedures should be established for the immediate security and recovery of downed aircraft. These procedures may provide for another aircraft to break from the formation and follow the disabled aircraft to the ground to determine if rescue is possible or feasible. Provisions to alter the formation after loss of aircraft should be made. All personnel should be thoroughly briefed regarding downed aircraft procedures.

E.3.7 Night Formation Flying. The operating procedures for night formation flying vary according to national doctrine. In a multinational operation the helicopter force/air mission commander is responsible for providing a thorough briefing.

Night formations should be controlled by radio or prearranged light signal codes.

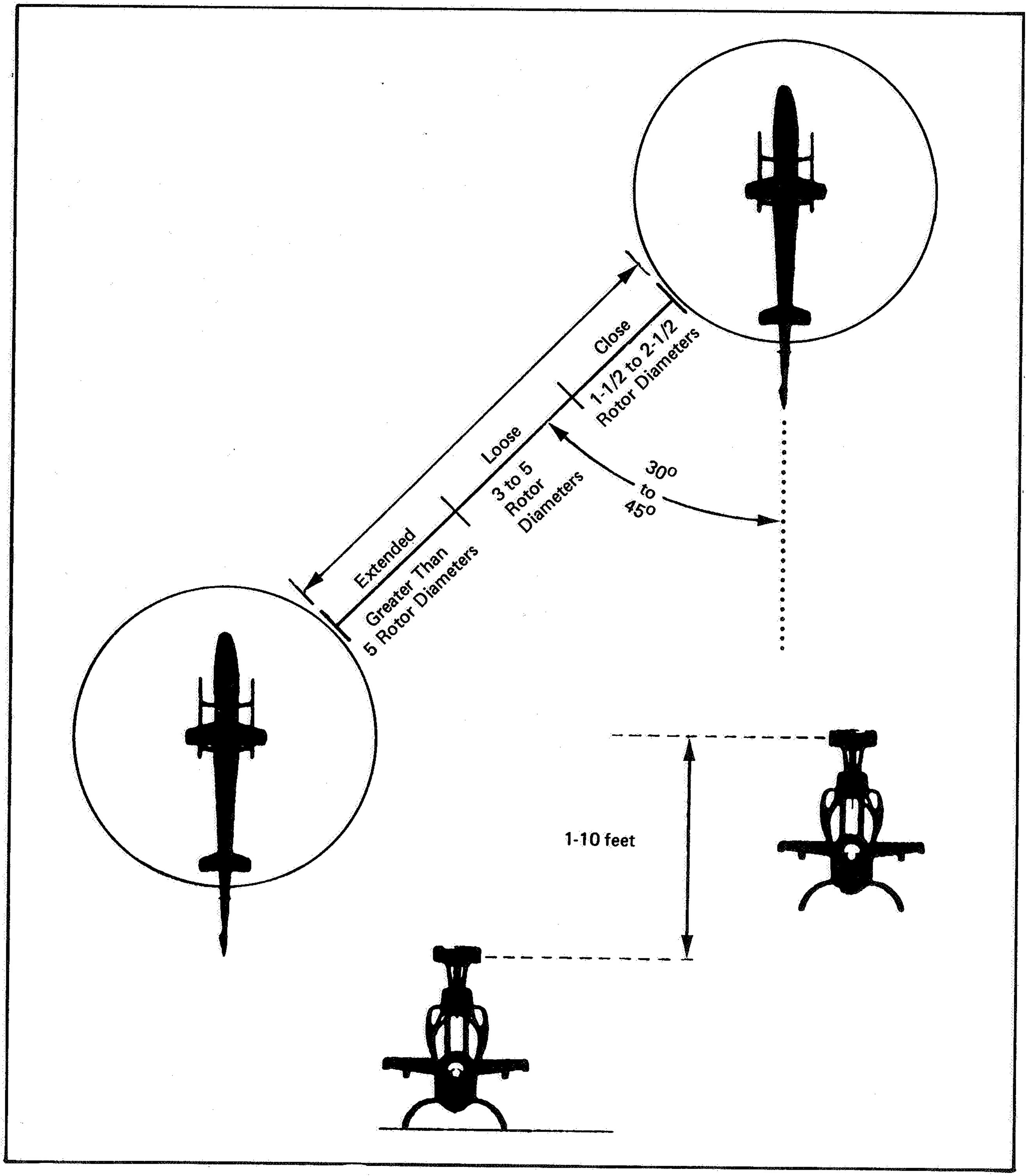

Close
1-1/2 to 2-1/2 Rotor Diameters
Loose
3 to 5 Rotor Diameters
Extended
Greater Than 5 Rotor Diameters
30° to 45°
1-10 feet

Figure E-1. Two-Helicopter Element Formation, Stepped Up

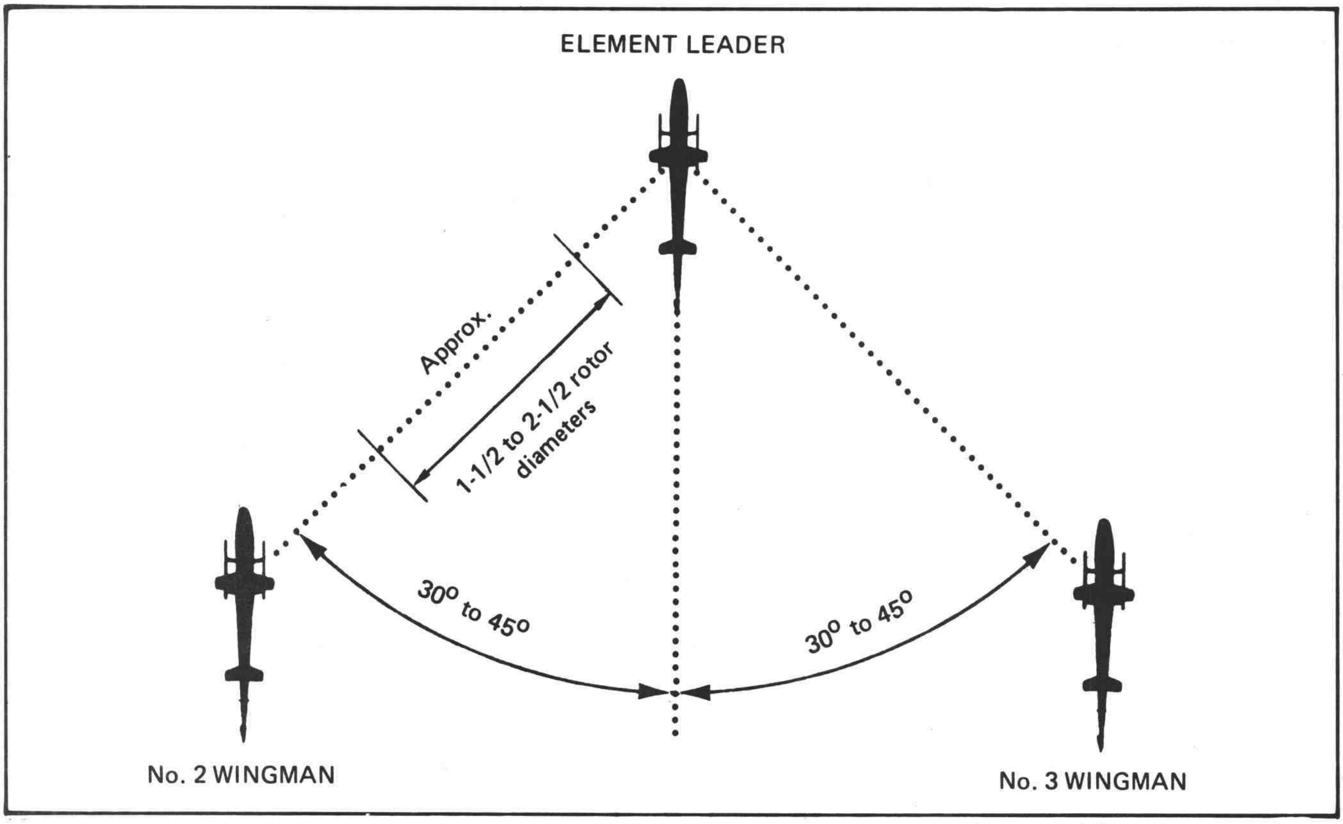


Figure E-2. Three-Helicopter Element V-Formation, Fixed Position

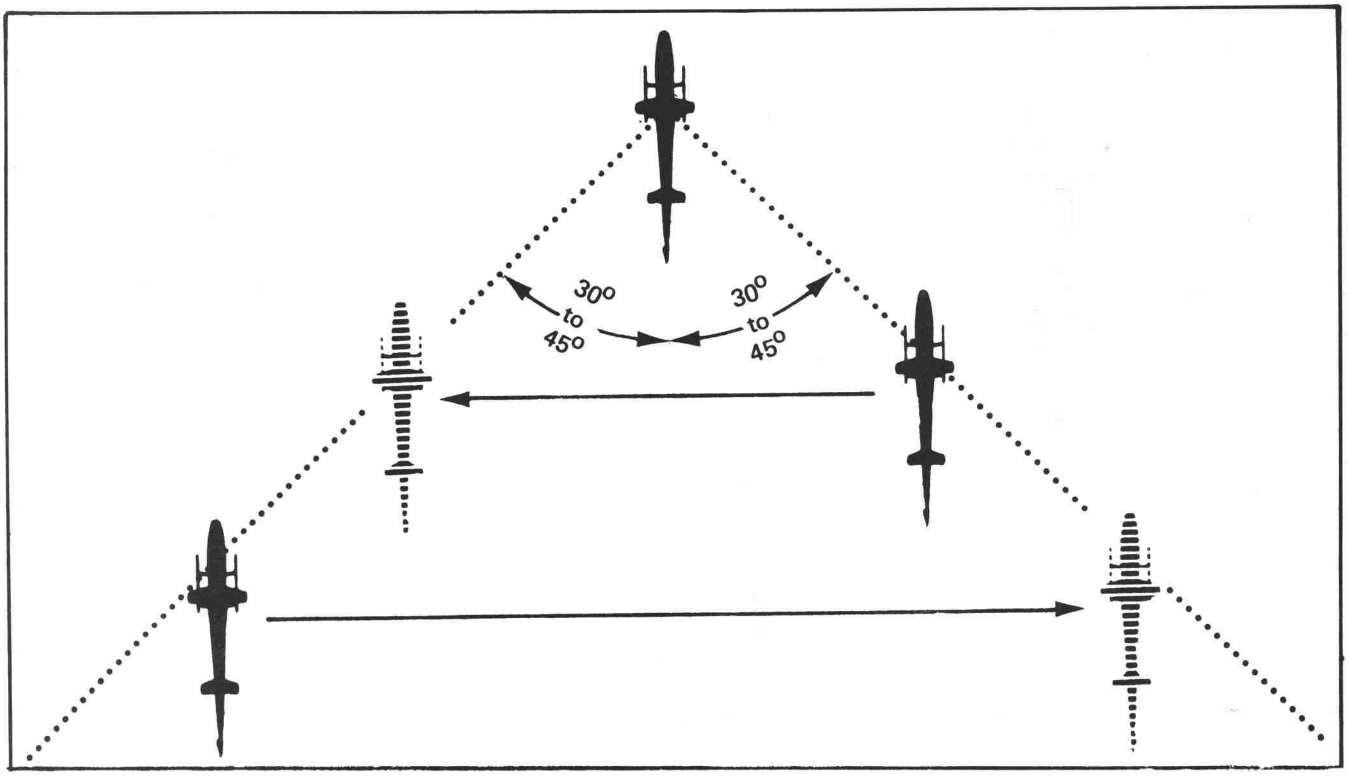


Figure E-3. Three-Helicopter Element V-Formation, Flexible Position

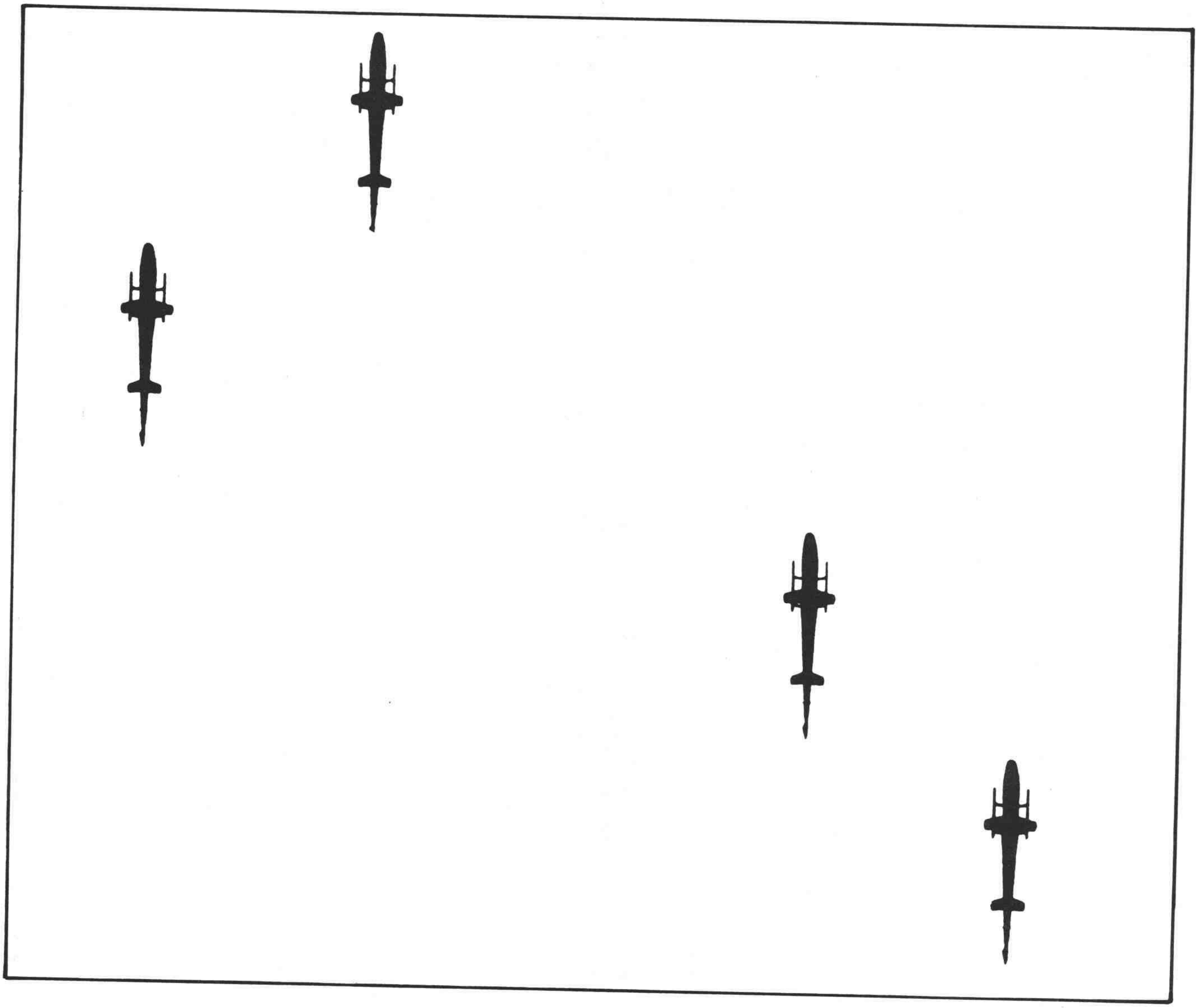


Figure E-4. Four-Helicopter Tactical Heavy Right Finger Formation

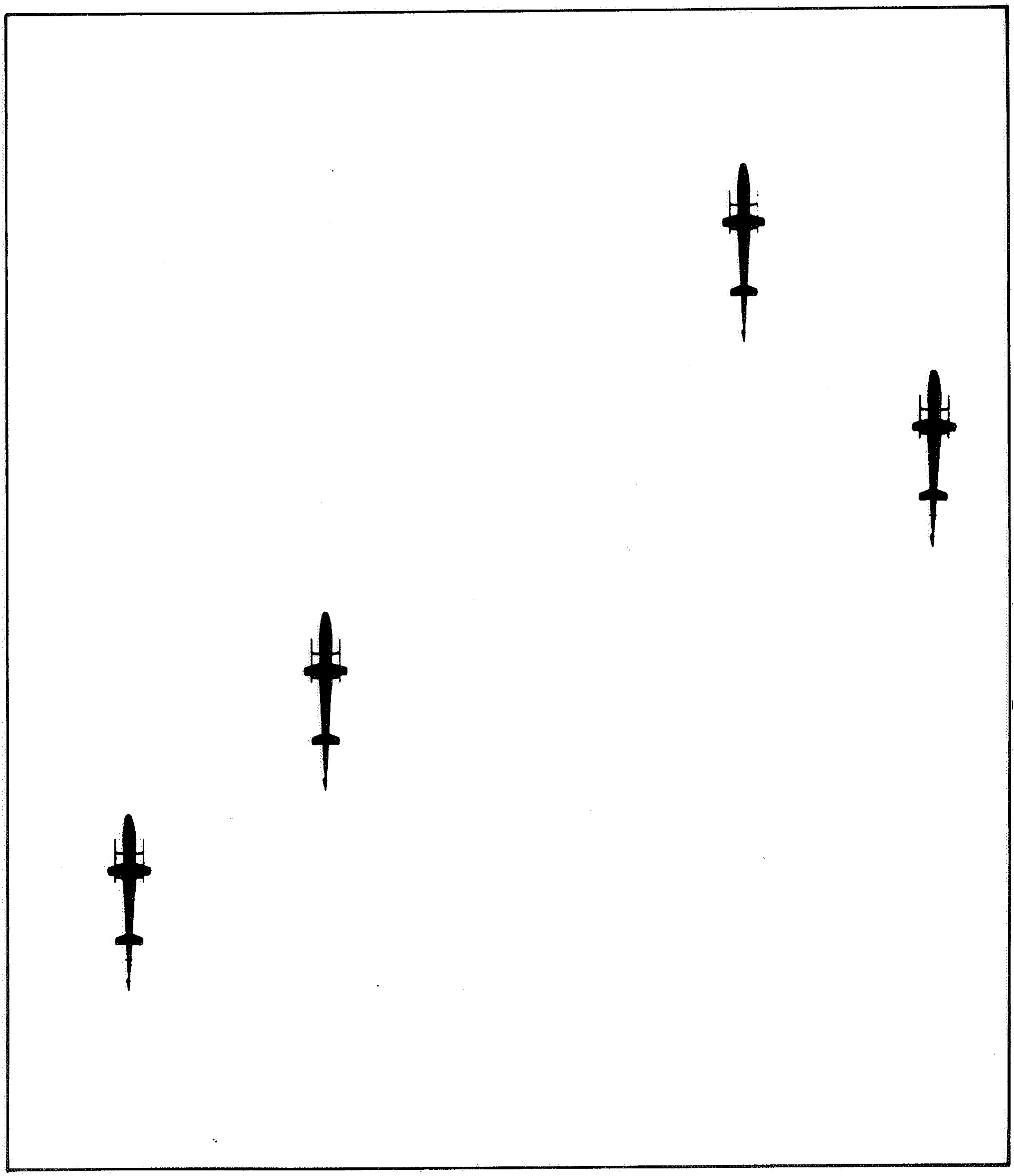


Figure E-5. Four-Helicopter Tactical Heavy Left Finger Formation

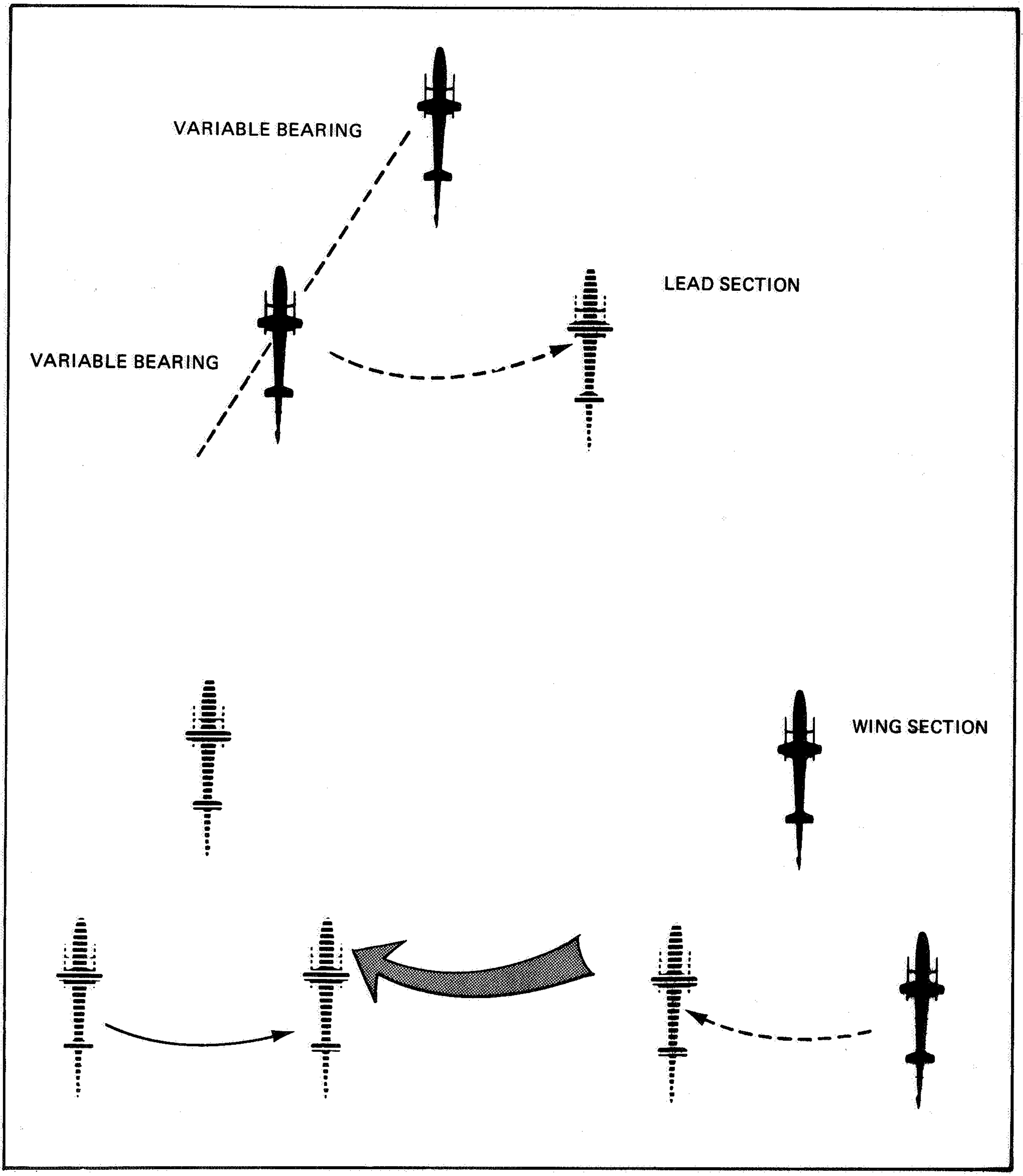


Figure E-6. Four-Helicopter Tactical Finger Formation, Variable Positioning

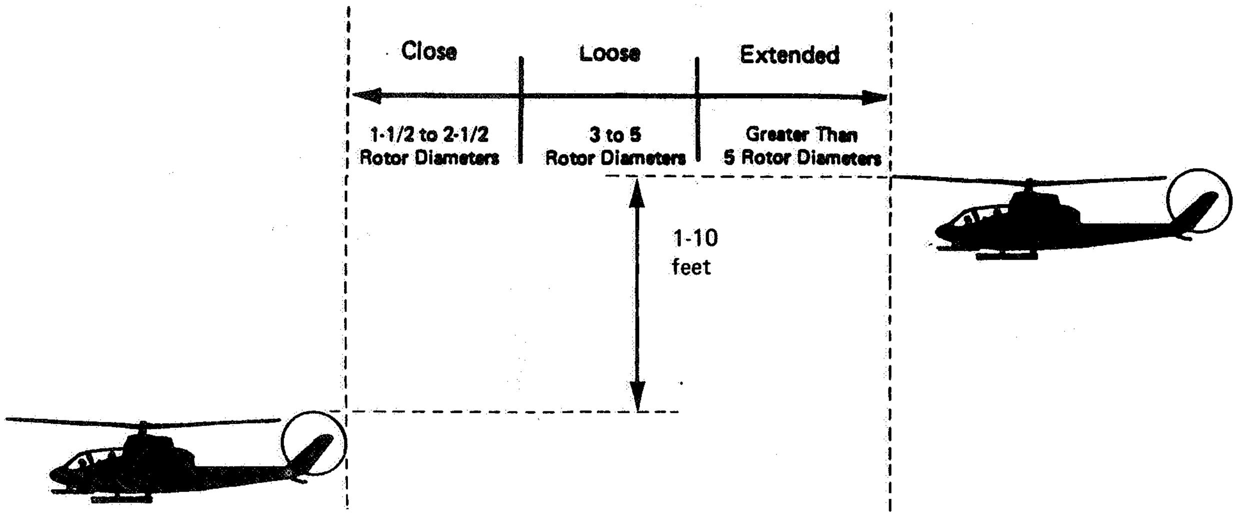

Close
Loose
Extended
1-1/2 to 2-1/2 Rotor Diameters
3 to 5 Rotor Diameters
Greater Than 5 Rotor Diameters
1-10 feet

Figure E-7. Two-Helicopter Element Trail Formation

Use of the helicopter's rotating beacon at night should be limited. The last aircraft of each flight, company, or battalion may be designated to use the rotating beacon to identify the rear of each formation.

Navigation lights should be in the dim position, if available, and each light should be shielded (masked) on the bottom side. They may be used as a signaling device (e.g., the leader switches the lights from dim to bright to indicate "PREPARE FOR TAKEOFF"). All personnel should be thoroughly briefed regarding use of lights as signals.

Lateral separation may be extended during night operations. Consideration must be given to the difficulty of determining distance when using only navigation lights as reference points.

E.3.8 Procedures on Encountering Adverse Weather. If a formation enters adverse weather conditions, the helicopters should remain in visual contact with each other if possible. The flight leader should make no radical turns or speed changes.

If the helicopters in formation cannot maintain visual contact with one another, a procedure must be executed that will ensure both vertical and lateral separation. Such a procedure should be a matter of unit standard operating procedure and unit aviators should be well trained in the procedure. These procedures will be thoroughly briefed to all aviators prior to initiation of flight. An illustration of one procedure is shown in Figure E-8.

E.3.9 Formation Evasive Maneuvers. Evasive maneuvers may be employed by the helicopter force/air mission commander to avoid or reduce the effects of intense ground or aerial fire. The need for rapid dispersion may arise at any time in a tactical situation, particularly if the formation comes under attack. Large aircraft formations may be divided into several smaller formations; however, these evasive tactics should be a matter of unit standard operating procedures. Subordinate helicopter units organic or attached must be briefed on these procedures. (See Formation Dispersion Maneuvers.)

E.3.10 Formation Dispersion Maneuvers. The order to execute a formation dispersion maneuver will be given by the formation commander or his designated subordinate.

The commander will reassemble the formation at a designated location and altitude or at predetermined rally points.

Figures E-9 through E-12 depict a method for dispersing typical formations.

E.4 IMPLEMENTATION OF THE AGREEMENT

This STANAG is considered implemented when a nation has issued the necessary orders/instructions to the forces concerned putting the procedures detailed in this agreement into effect. Figure E-13 provides information on national ratifying references and details of implementation.

E.5 TERMINOLOGY

The following terms and definitions are for the purpose of this STANAG.

E.5.1 Formation. A formation consists of two or more aircraft under the command of a designated leader.

E.5.2 Unit Indication

1. Element/Section — a two- or three-helicopter formation. The two-helicopter element is the basic building block for all larger formations.

2. Flight/Division — four or more helicopters in two or more elements/sections.

3. Company/Squadron Formation — a formation of two or more separate flights/divisions. The number of helicopters is determined by the size of the company/squadron.

4. Battalion/Wing Formation — a formation of two or more companies/squadrons.

E.5.3 Relative Positions

1. Echelon Formation — a formation in which single aircraft, elements, divisions, or formations (each in identical formation) are placed one behind another with a lateral and even spacing to the same side.

2. Trail/Line Astern — a formation in which all aircraft are in single file, each directly behind the other.

3. Heavy Left/Right Formation — a formation composed of two or more elements in which the greater number of elements are positioned to the left/right of the lead aircraft.

4. Finger Formation — a flight of four aircraft, or of two elements/sections of two aircraft, in a heavy left/right formation.

5. Staggered Trail (left/right) — a formation composed of two or more elements/sections (of two aircraft) flying in column. Flying

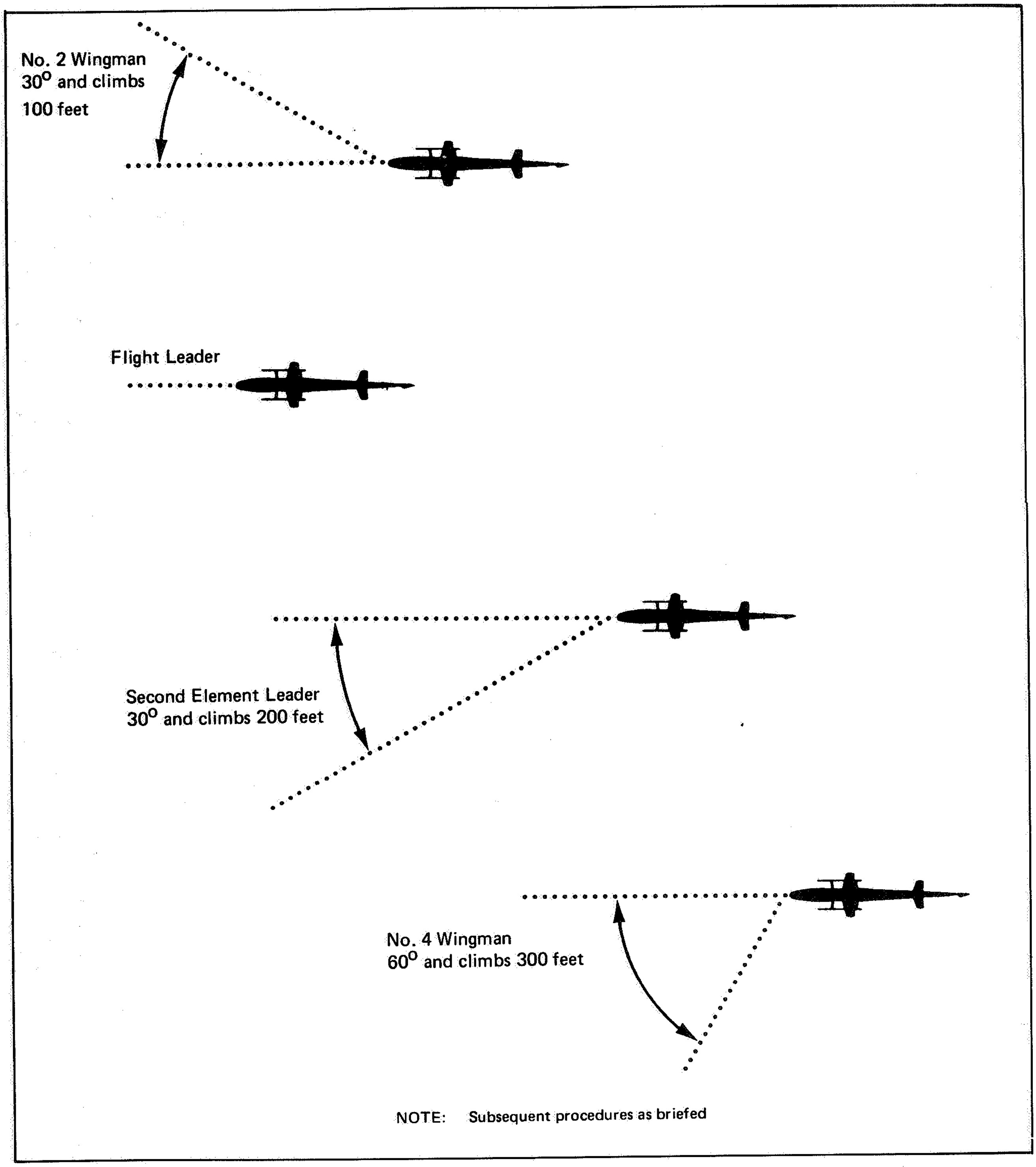
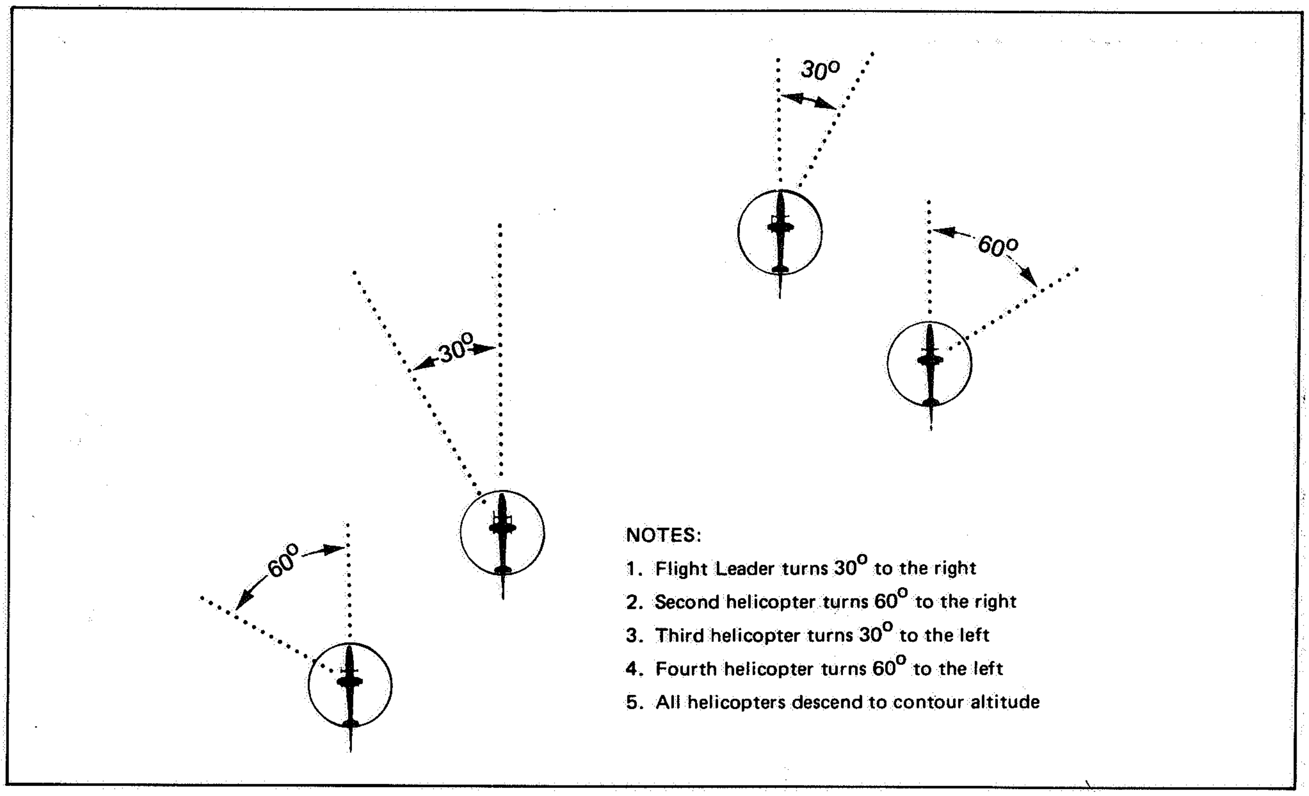


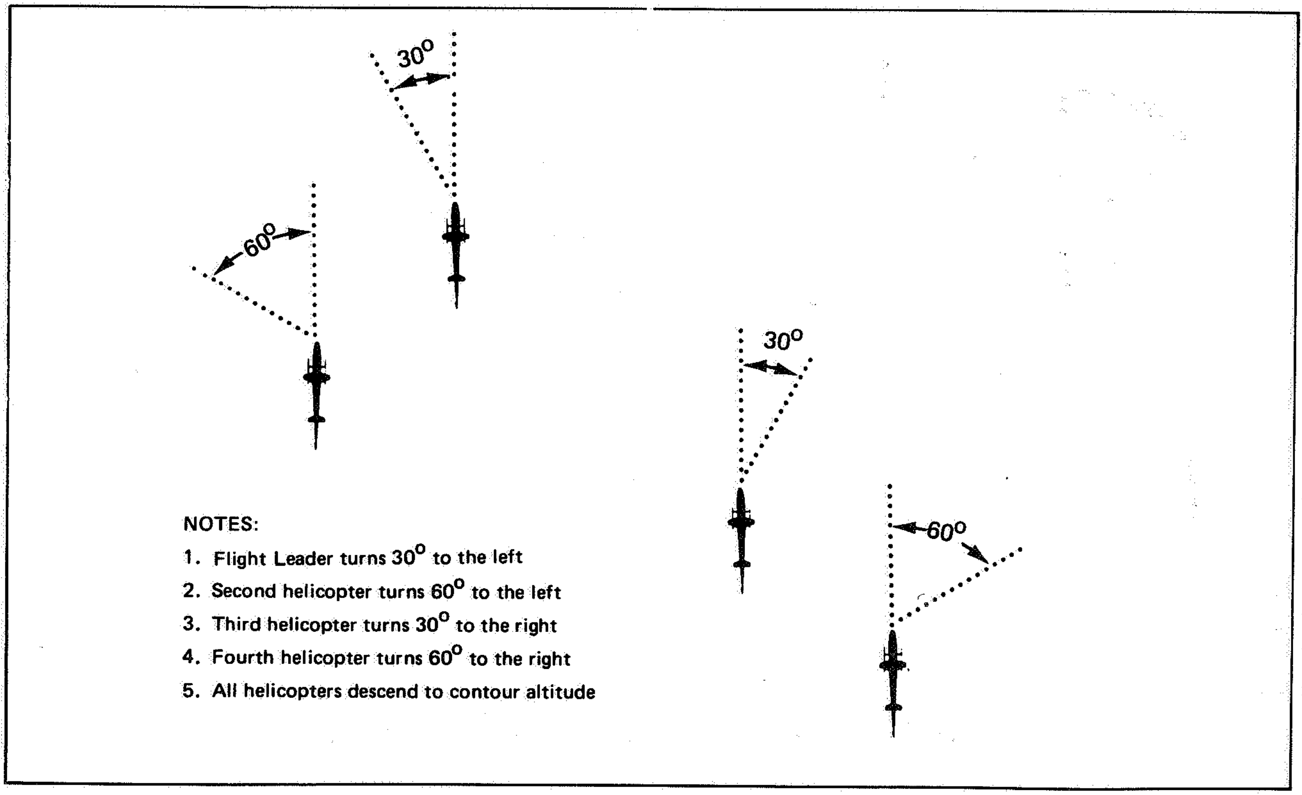
Figure E-8. A Typical Procedure When Visual Contact Cannot Be Maintained Upon Entering Adverse Weather



NOTES:

1. Flight Leader turns 30° to the right
2. Second helicopter turns 60° to the right
3. Third helicopter turns 30° to the left
4. Fourth helicopter turns 60° to the left
5. All helicopters descend to contour altitude

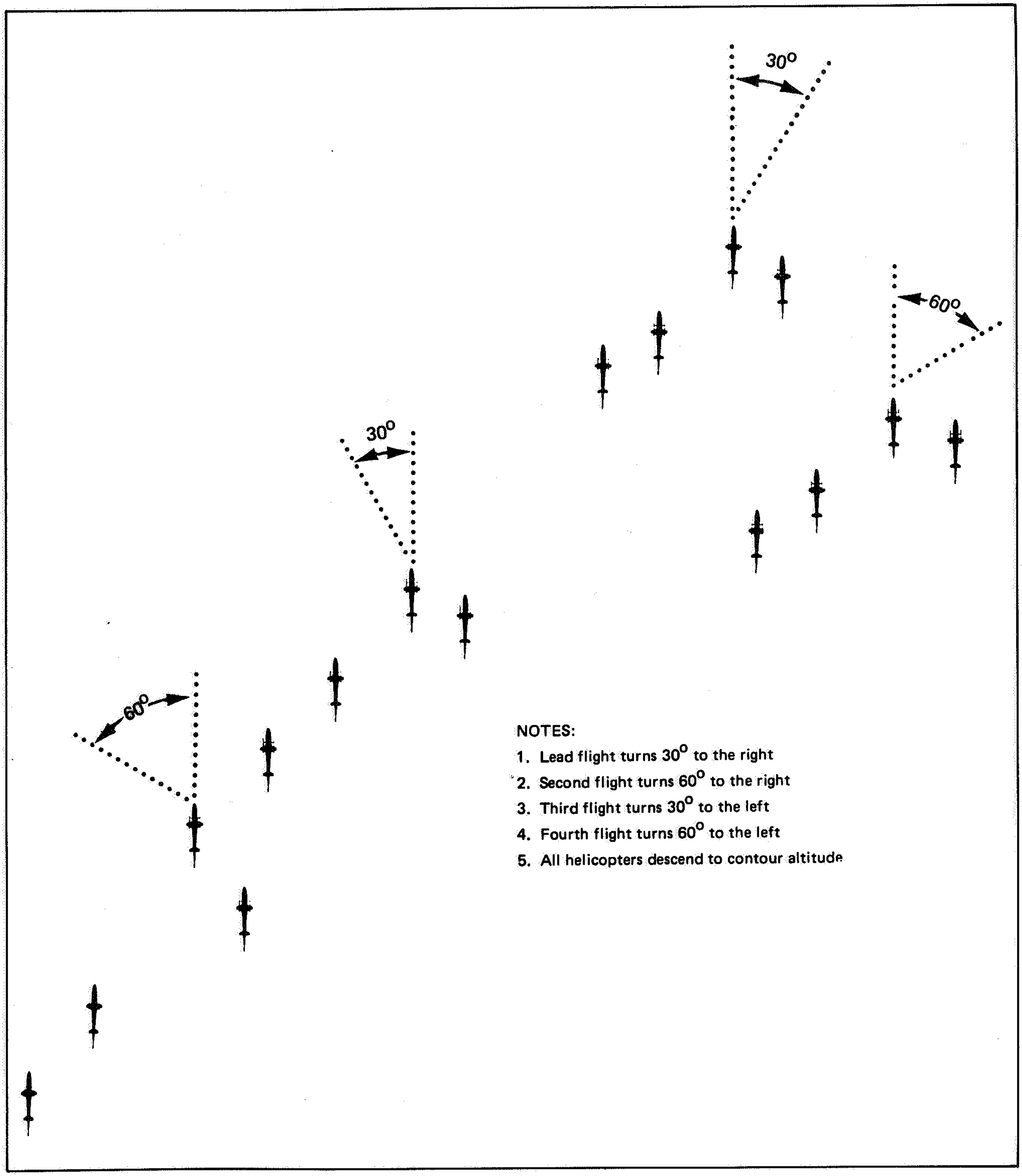
Figure E-9. Flight Heavy Left Finger Formation



NOTES:

1. Flight Leader turns 30° to the left
2. Second helicopter turns 60° to the left
3. Third helicopter turns 30° to the right
4. Fourth helicopter turns 60° to the right
5. All helicopters descend to contour altitude

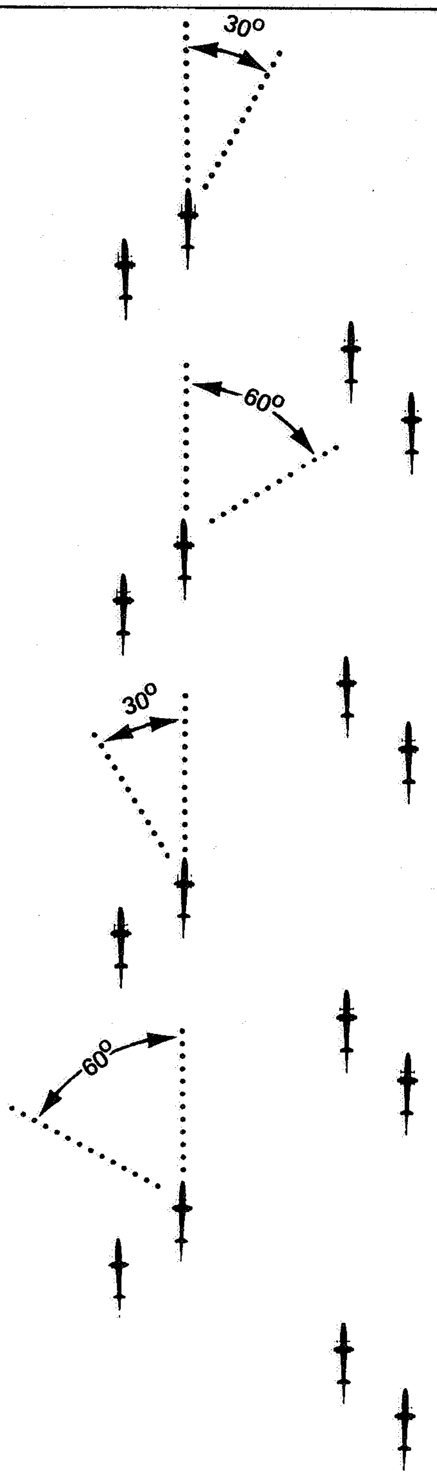
Figure E-10. Flight Heavy Right Finger Formation



NOTES:

1. Lead flight turns 30° to the right
2. Second flight turns 60° to the right
3. Third flight turns 30° to the left
4. Fourth flight turns 60° to the left
5. All helicopters descend to contour altitude

Figure E-11. Company Heavy Left (Flights Heavy Left)



NOTES:

1. Lead flight turns 30° to the right
2. Second flight turns 60° to the right
3. Third flight turns 30° to the left
4. Fourth flight turns 60° to the left
5. All helicopters descend to contour altitude

Figure E-12. Company Column (Flights Heavy Right)

NATION	NATIONAL RATIFYING REFERENCE	DATE OF IMPLEMENTATION		SERVICES IMPLEMENTING
		FORCAST	ACTUAL	
BELGIUM	VS3/Tpt/MAS/73/8979 dated 14 Sept 73		Feb 74 Feb 74 Feb 74	NAVY ARMY AIR
CANADA	DLA 2260 dated 28 Nov 73		Feb 74 Feb 74 Feb 74	NAVY ARMY AIR
DENMARK	FKO/0 308.6/3627/00 1-4434 dated 28 Sep 73		NOT IMPLEMENTING	
FRANCE	144/EMAA/3/OP/OTAN/NC dated 14 Nov 73		Feb 74 Feb 74 Feb 74	NAVY ARMY AIR
Federal Republic of GERMANY	BMVg-Fu 8 IV 1-Az.03-51-40 dated 27 Feb 75		Mar 75 Mar 75 Mar 75	NAVY ARMY AIR
GREECE	F.HNR/MAS/AIR-4-73/5432 dated 10 Oct 73	May 74	May 74	ARMY AIR
ITALY				
LUXEMBOURG	NOT PARTICIPATING			
NETHERLANDS	KAB 5990 K dated 16 Oct 73			NAVY AIR
NORWAY	MAS 1045/73/B/FO/AIR/RL/RB/ STANAG 3627 dated 16 Aug 73		Jul 74	AIR
PORTUGAL	974/RA dated 6 Nov 73		Feb 74	AIR
TURKEY	Gn.P.P:2307-376-73/AND.D.MAS S(3627)5217 dated 19 Dec 73		Aug 74	ARMY
UNITED KINGDOM	AF/3608/69 dated 25 Jan 74			NAVY ARMY AIR
UNITED STATES	AF/LGXI dated 16 Oct 73	Dec 76	May 74 Feb 74	NAVY ARMY AIR

NOTE: If no details are shown in the columns, the nation has not notified MAS of its intentions.

Figure E-13. National Ratifying References and Details of Implementation (STANAG 3627)

Left/right is determined by the echelon position of wingmen.

6. Column Formation — a formation in which elements, flights, or formations (each in identical formation) are positioned one directly behind the other.

E.5.4 Techniques and Procedures

1. *Free Cruise and Tactical* Flight Techniques — there are two techniques which allow a great degree of freedom of maneuvers in certain helicopter formations.

(a) *Free Cruise* — free cruise is the technique whereby the wingman maintains a specified distance from the leader but may vary the bearing from the leader during turns. This distance is measured perpendicular to the lateral line that passes through the tail region of the leader to the lateral line that passes through the nose region of the wingman. The wingman, as he maintains this distance, is free to maneuver during turns in the airspace extending from 45° on either side of the leader's tail. This technique applies to flight, company, or larger formations.

(b) *Tactical* — although similar to *free cruise*, this technique allows even more freedom of maneuver than does *free cruise*. It is a technique whereby both bearing and distance of wingman from section leaders, and of sections from the lead section, may be varied during flight.

2. Rendezvous — a prearranged meeting at a given time and place from which to begin an action or phase of an operation, or to which to return after an operation (e.g., to assemble, meet, or arrive at a rendezvous; to meet with another or others in rendezvous).

3. Join-up — to form separate aircraft, elements, or flights into a specific flight formation.

4. Rendezvous and Join-up — to assemble and form into a specific flight formation.

E.5.5 Other

1. Leader, Lead, Lead Helicopter — the helicopter at the head of a helicopter formation designated to perform certain command and air control functions.

2. Nose-to-Tail Distance — the distance from the tail region of a specified formation leader to the nose region of a particular wingman; or, in multiple formations, the distance from the tail region of one formation to the nose region of another formation.

3. Wingman — an aviator who flies at the side and to the rear of an element leader, commonly in a two-helicopter formation; also, the helicopter flown in this position.

4. Stepped Up (Separation) — the vertical separation between the wingman and the element leader measured from the altitude of the leader upward to the altitude of the wingman.

Example: the wingman was flying a 3-foot, stepped-up position on the leader.

APPENDIX F

Night Vision Goggles

F.1 GENERAL CHARACTERISTICS

The characteristics discussed in this appendix apply to both the PVS-5 and ANVIS goggles.

Night vision goggles (NVGs) do not magnify an image. An object or person viewed through the goggles at a given distance will be the same relative size as seen in the day without the goggles. Objects that are hard to see during the day — wires, camouflaged equipment — are also difficult to detect with the goggles. Resolution, which is directly related to the availability of ambient light, is not as good with NVGs. During periods of high ambient light, resolution is improved and objects can be identified at greater distances.

The best visual acuity using the current NVG system is 20/50.

Depth perception and estimation of distances are affected when using goggles. For the first 20 feet in front of the user, depth perception is decreased with NVG. Beyond 20 feet and up to 500 feet, depth discrimination is roughly equal to that of the unaided eye, while depth perception beyond 500 feet is reduced by NVG usage. For distance viewing, stereopsis (the ability to achieve a sense of depth perception by seeing two slightly different images with each eye) is reduced with NVGs. This is mainly due to reduced vsual acuity.

Color is distorted when using goggles.

1. Monochromatic vision (single color). The picture seen with NVG is monochromatic and has a green hue. It is also slightly blurred compared to normal daylight vision.

2. Chromatic adaption. When the shades of green light present in the NVG are viewed for several minutes and the NVGs are removed, the pilot may see one of two things. If the aviator looks at the lighter of two backgrounds, he may see the complement or opposite of the green color to which he had become adapted. If he looks at the darker of the two backgrounds, he might see an after-image of the same color as the green light to which he had become adapted. An after-image may be expected following viewing with NVGs. It is a normal physiological phenomenon and need not be of concern.

Note

> After removal of the goggles, the most common after-image is the so-called brown eye syndrome (a reddish brown titn).

The field of view (FOV) is limited to 40°. This does not allow the use of normal peripheral vision. Scanning patterns should be increased to compensate for a limited FOV.

Detection ranges are largely a function of the existing light conditions. Moving targets with contracting backgrounds or targets with a reflected or generated light source can be identified at greater ranges. Target acquisition capabilities are:

1. Under low to medium ambient light conditions (quarter moon), personnel can be detected at ranges up to 400 meters (1,310 feet). Vehicular targets and other large stationary objects may be acquired at ranges

up to 2,000 meters (6,560 feet). Acquisition in excess if 3,000 meters (9,840 feet) is possible when vehicles are moving. Recognition of prominent terrain features is possible at ranges up to 3,000 meters (9,840 feet).

2. In medium to high ambient light (quarter moon to full moon), all detection ranges are significantly increased. During field tests, major terrain features were identified at distances exceeding 16 kilometers (9.9 miles), and buildings at ranges exceeding 3,000 meters (9,840 feet).

F.2 EFFECT OF LIGHT ON NIGHT VISION GOGGLE

Any light source within the cockpit that is detectable with the unaided eye may degrade the aviator's ability to see outside the aircraft. The adverse effect of aircraft lighting on the goggles is greatest during conditions of low ambient light. As ambient light increases, aircraft lighting has less effect on the goggles.

F.2.1 Cockpit Lighting

F.2.1.1 AN/PVS-5. The PVS-5 is responsive across the entire visible light spectrum peaking in the red portion and continuing into the near infrared (IR) spectrum (Figure F-1). Cockpit compatibility is achieved by dimming or eliminating light sources that are too intense for the NVGs. Because the goggles pick up reflected light, glare sources should be eliminated. As a result, decals should be covered; the cockpit panel should be painted black; instrument lights should be dimmed to a point where no windscreen glare is evident through the goggles; and lights, which cannot be adequately dimmed, should be taped to reduce the amount of light they emit.

F.2.1.2 AN/AVS-6 (ANVIS). The Aviator's Night Vision Imaging System (ANVIS) is a pilot night vision device utilizing third generation intensification tubes which are more sensitive to light than the PVS-5. Red, white, or yellow light will *shut down* the ANVIS, whereas blue or green light will affect it to a lesser degree (Figure F-1). The dimming techniques used for the PVS-5 are not effective with the ANVIS due to its increased sensitivity to light.

F.2.1.3 Cockpit Lighting Modification. Efforts are underway to modify helicopter cockpit lighting to blue/blue-green. In this manner, cockpit lighting will be NVG compatible.

F.2.2 Dark Adaptation. No dark adaption period is necessary for effective viewing through the night vision goggles. In fact, viewing through the goggles for a short peirod of time shortens the normal dark adaption period. After using NVGs, it takes the average individual 1 to 3 minutes to reach the 30-minute dark adaption level.

F.2.3 Object Identification. When viewing an area illuminated by an artificial light — flare, landing light, built-up area — the aviator's ability to see an object outside the periphery of the area being illuminated will be limited. His ability to view objects within the area being illuminated depends on the intensity of the light and the distance the object is away from the observer. Direct viewing of the light source should be avoided. If exposed to a high intensity light, the goggles will adjust to the light. Normal viewing with the goggles is regained by turning away from the light source.

With the goggles, the aviator will be able to detect light sources which are not visible to the unaided eye. Light from such sources as vehicles, flashlights, and burning cigarettes can be detected at great distances. The capability of goggles to detect these light sources improves as the ambient light level decreases.

F.3 DEFECTIVE TUBES

Tube operation must be checked prior to each flight. If any of the following conditions exist, the appropriate action should be taken:

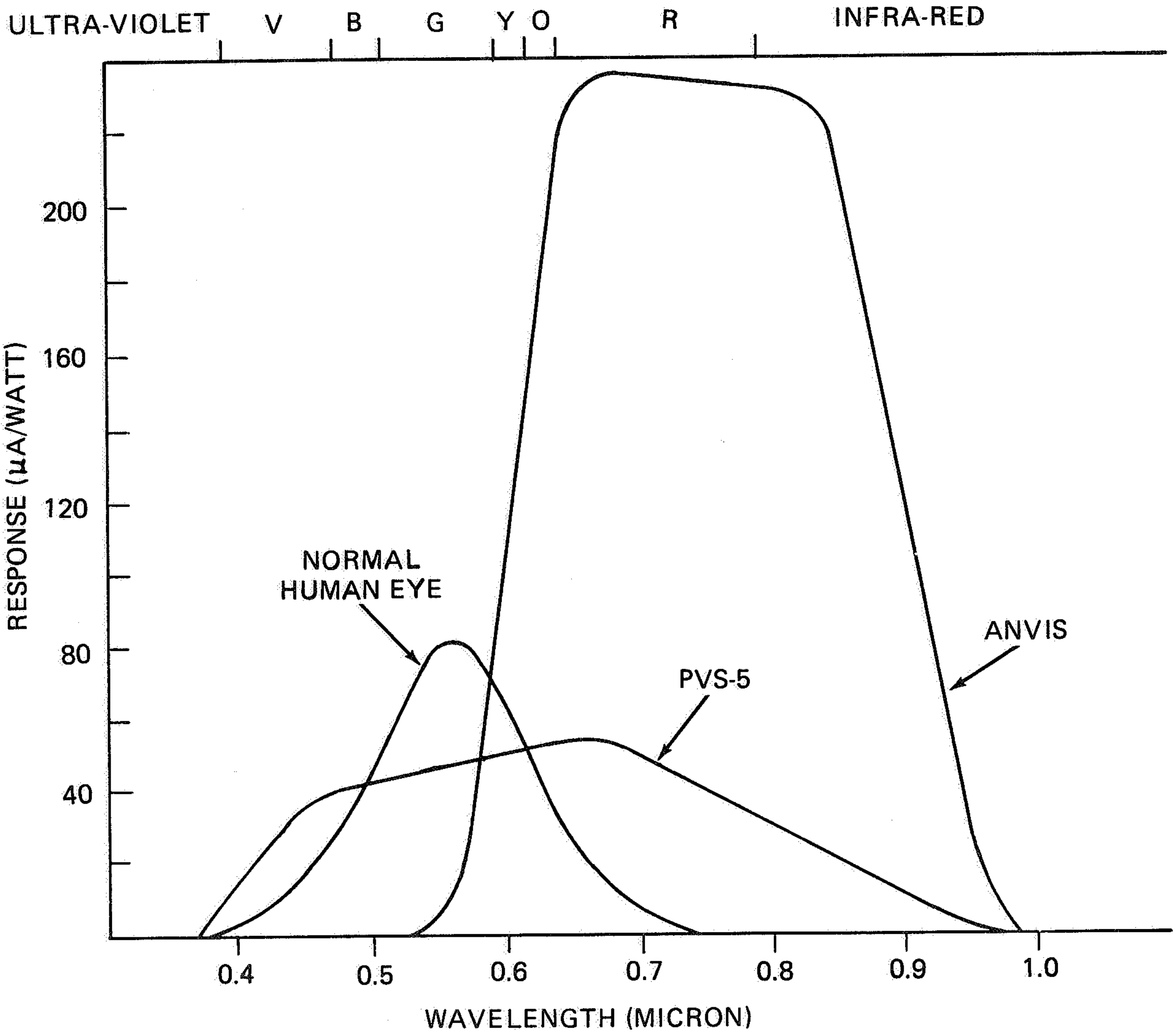


Figure F-1. Light Spectrum and Night Vision Goggle Response

F.3.1 Shading. Both goggles' tubes should portray a perfect circle. If shading is present, a fully circular image will not be seen (Figure F-2). Shading always begins on the edge and moves inward. The NVG should be replaced.

F.3.2 Edge Glow. A bright area in the outer portion of the viewing area indicates edge glow (Figure F-3). To check for this defect, block out all light by cupping a hand over the objective lens. The NVG should be replaced.

F.3.3 Bright Spots/White Dot. Spots may flicker or may appear constant (Figure F-4). Check by cupping a hand over the objective lens blocking out all light. Bright spots will still be visible. If a white dot exists anywhere, replace the tube. A white dot is caused by a pinhole in the phosphorous screen.

F.3.4 Flashing, Flickering, or Intermittent Operations. The NVG appears to flicker on and off, or the output flashes. This can occur in one or both monoculars. If more than one flicker is seen, the troubleshooting chart in the technical manual should be considered.

F.3.5 Dark Spots. Black marks which may look like spots or streaks are acceptable as long as the marks do not interfere with the mission (Figure F-5). No action is required.

F.3.6 Fixed Pattern Noise/Honeycomb. A faint honeycomb pattern is acceptable as long as the pattern does not interfere with the mission (Figure F-6). The honeycomb is most prevalent in high light levels.

F.4 AN/PVS-5

F.4.1 Description. The AN/PVS-5 (PVS-5) NVG is a helmet-mounted night vision device (Figure F-7). The system uses light amplification to provide night vision and is not detectable when operated in this mode. It does not provide an image magnification capability. An auxiliary infrared light source is incorporated into the system providing illumination for viewing to a distance of approximately 6 feet. When operating in the IR mode, detection by Threat Forces is possible. The PVS-5 has proven to be very reliable.

F.4.2 Features. The PVS-5 goggles consist of two identical monocular assemblies (tubes) mounted in an adjustable frame. Each tube has an objective lens, an image intensifier assembly, and an eyepiece (Figure F-8). Operation of the system is controlled by a three-position switch (ON-OFF-IR). When the switch is placed in the ON position, the system is activated and viewing with the goggles is possible. The goggles should not be turned on in a lighted room or in the daylight unless the objective lens caps or dayfilters are in place. A pinhole in the objective lens cap provides sufficient light to conduct an operational test without damaging the tubes. Exposure to sunlight or high intensity light damages the tubes.

The NVG housing assembly is constructed of a plastic material and lined with a cushion which rests on the cheekbones. The entire unit weighs 32 ounces with the Arctic kit and demisting shields. It extends approximately 6.5 inches in front of the flight helmet.

To improve image acuity, the goggles must be focused for the range at which an object is being viewed. The focusing range is from 10 inches to infinity. Adjustments are made by focusing each tube cylinder.

The PVS-5 has a 40° field of vision which limits peripheral vision.

At present, eyeglasses are not worn with goggles.

F.4.3 Failures. Failures in PVS-5 goggles are normally attributed to weak batteries or broken wires.

Currently, there is no method to test the condition of the PVS-5 tubes. In most cases where failures have occurred, users have been provided advance warning. The most common indication of impending failure is a significant

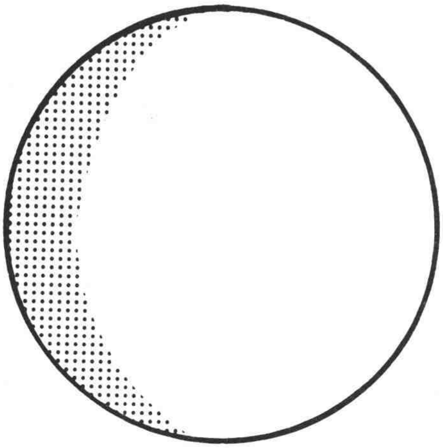


Figure F-2. Shading

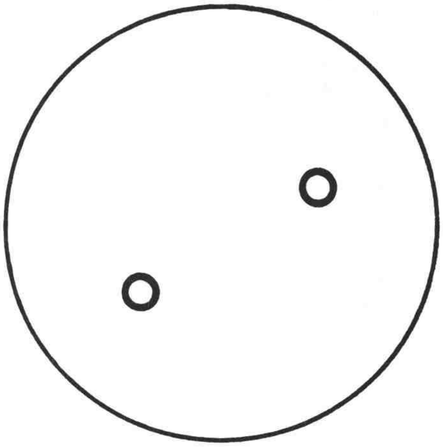


Figure F-4. Bright Spots/White Dot

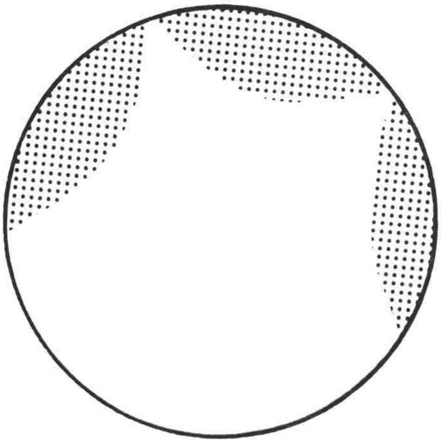


Figure F-3. Edge Glow

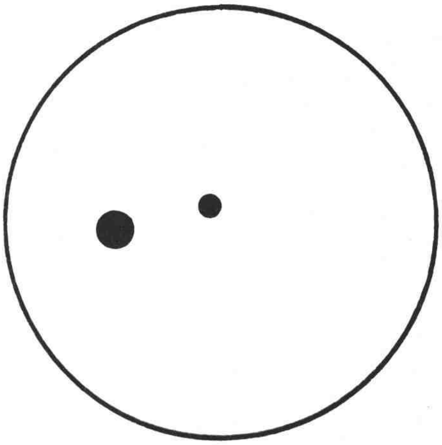


Figure F-5. Dark Spots

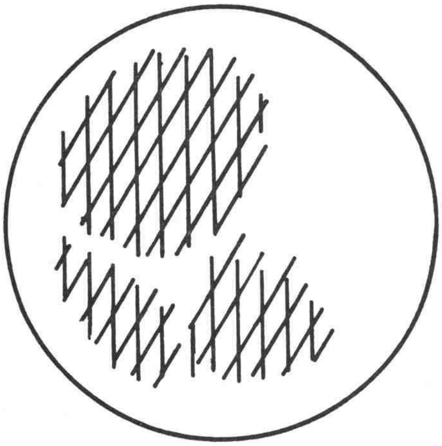


Figure F-6. Fixed Pattern Noise/Honeycomb

differential in light intensity between the two tubes. In other cases, loss of resolution begins at the periphery of the viewing area and moves inward. Additionally, a blinking condition may occur in one of the tubes, or one tube may completely shut down. When any of these conditions is experienced, the weak tube should be turned in for repair.

Presently, a 2.7-volt mercury battery is used to operate the PVS-5 system. Installation of the battery is performed by the user. The battery is recoverable, but not rechargeable.

Each aircrew member wearing PVS-5s should carry at least one extra battery. The extra battery should be placed in a location that is easily accessible to the user in flight. Each user must be proficient in changing the battery in the dark without removing the goggles.

The state of charge of the battery cannot be determined. A blinking or dimming condition in either or both tubes may indicate that the battery is weak and should be replaced. The normal battery life is approximately 12 hours at 70 °F. The battery will rapidly discharge at the end of its useful life. Accurate records should be maintained so that the aviator knows how many hours the battery has been used. When there is doubt as to how many hours the battery has been used, it should be replaced. Each aircrew member should ensure that the battery time for his set of goggles does not exceed 10 hours during a flight. If this policy is followed, it is unlikely that two aircrew members would experience battery failure at the same time. Batteries that have exceeded the recommended shelf life should not be used. Data has shown that the life of these batteries is significantly reduced.

F.4.4 Fitting the AN/PVS-5. Proper fitting of PVS-5 is essential to ensure comfort and minimize fatigue. The flight helmet must be properly fitted to the head before adjustments are made to the headstraps which attach the goggles to the helmet. Proper adjustment of the helmet headbands and nape strap will prevent the helmet from rotating forward and down.

Headstraps are supplied with each set of NVGs. The headstraps provide three attaching points to the helmet. Two male snaps and two 2-inch Velcro strips must be attached to the helmet. Material and instructions for preparing the helmet are enclosed in the case with the NVG. A rubber headstrap is provided for wear under the helmet. The helmet is not configured for external attachment of the goggles without modification.

F.4.5 Adjustments. There are three adjustments that can be made to the goggles to correct for individual differences. These include:

1. The distance between the tubes can be varied by releasing the lever clamp. This adjustment should be made so that the tubes are parallel and properly aligned with the eyes. Improper adjustment will result in either cross-eyed or diverging (walleyed) vision. This will increase eye fatigue and may cause headaches.

2. The binocular assembly can be adjusted to a position that is comfortable to the eyes.

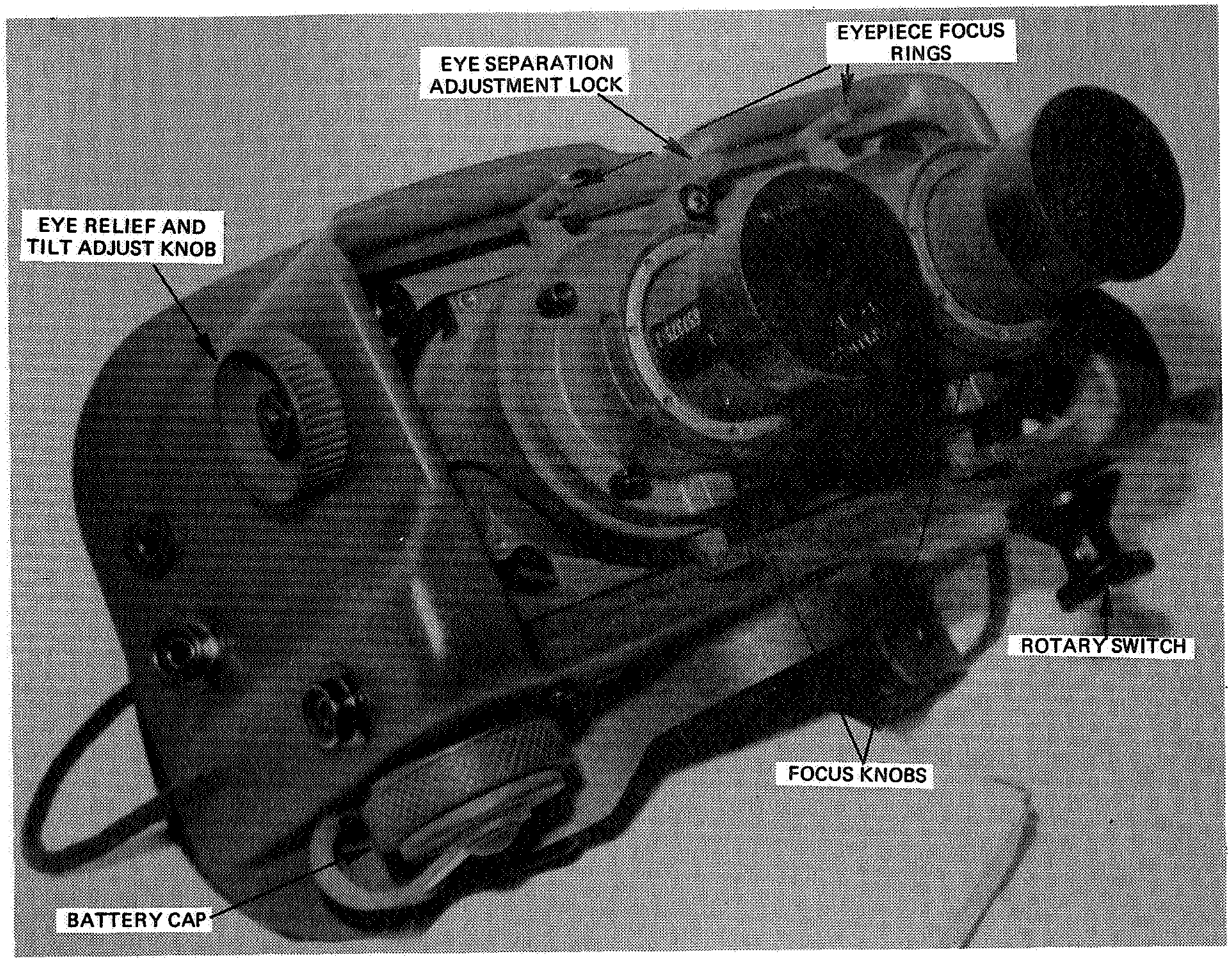

EYEPIECE FOCUS RINGS
EYE SEPARATION ADJUSTMENT LOCK
EYE RELIEF AND TILT ADJUST KNOB
ROTARY SWITCH
FOCUS KNOBS
BATTERY CAP

Figure F-7. Night Vision Goggles (PVS-5)

Adjustments are made by loosening the clamp knobs on each side of the goggles. The goggle assembly can then be moved fore and aft and tilted up or down to the desired position for the most comfortable viewing.

3. Each tube is equipped with a diopter adjustment ring. This adjustment allows the aviator to correct for visual deficiencies such as myopia and hyperopia. The range of the diopter is a +2 to -6. The diopter does not correct for astigmatism. Individuals with a 1.00 or greater diopter of astigmatism will experience blurred vision when viewing through goggles.

(a) Diopter adjustments should be accomplished one tube at a time.

(b) To determine the correct diopter adjustment, the diopter ring should be turned until the light is seen very distinctly. This procedure is performed for each eye and for each different set of goggles that are used. Further adjustments are not necessary to focus on objects at closer ranges.

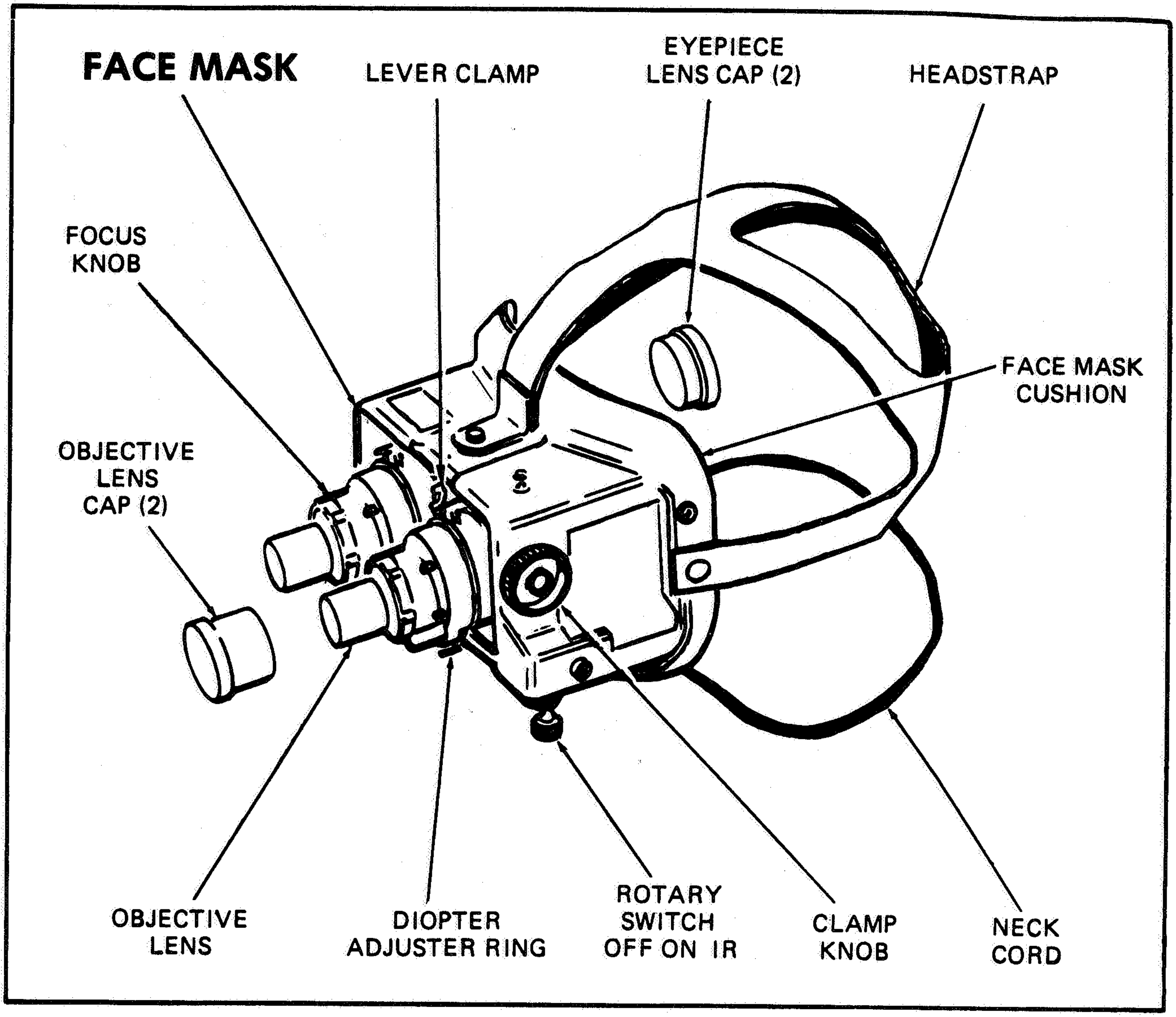


Figure F-8. Night Vision Goggles

F.4.6 Environmental/Care Consideration. An awareness of environmental conditions that affect the use of NVGs is essential to ensure reliable performance of the goggles. The following preventive measures should be used when the specific environmental condition prevails:

The PVS-5 goggles must be properly maintained in accordance with TM-11-5855-

238-10/20. Special care must be exercised in dusty, sandy, and humid conditions.

There may be a tendency for moisture to form on the eyepieces when they are initially placed on the head. This condition is caused by heat and moisture given off by the body. It is more noticeable during cold temperatures when there is a significant temperature differential between the goggles and the body. Demisting shields are provided to prevent accumulation of moisture on the lenses. Antimisting chemicals or chemically treated cloths should not be used on the demisting shield or lenses.

The Arctic kit battery holder should be used in freezing temperatures. This device allows the aviator to operate the goggles with the battery inside his pocket where it is protected from cold temperatures.

Whenever the goggles are not being worn, the lens covers should be installed. There is a tendency for the user to suspend the goggles from the neck by the safety strap without covering the objective lenses. As a result, the objective lenses may be scratched by the buckle on the safety belt. When it is necessary to suspend the goggles from the neck, but impractical to install the lens covers, the safety strap should be shortened to prevent the lens from contacting the safety belt buckle. This may be accomplished by rotating or twisting the safety strap. A knot should never be tied in the safety strap, as this prevents removal of the goggles over the helmet.

When installing or removing a battery, ensure the selector switch is in the OFF position. If the switch in ON, intermittent electrical contact is made when unscrewing or screwing the battery cap, causing a flicker or power surge to the tubes which may cause burn spots on the tubes.

The goggles should always be stored with the battery removed. There is a possibility of inadvertently turning the switch on when placing them in the case. If goggles are stored for an extended period of time with the battery installed, corrosion can develop.

Rough treatment of the goggles must be avoided. Mistreatment of the goggles may cause a failure of one or both tubes or the electrical system. If the goggles do not operate when the switch is turned on and the battery is fully charged, the wiring should be checked for breaks or for the presence of oxidation at the terminals.

CAUTION

- Never store in a wet carrying case.
- Allow goggles to dry before storing.

F.4.6.1 Operation in Freezing Temperatures

1. Install demist shields.
2. Remove battery cap from night vision goggles. Stretch battery cap in plastic retainer over button to remove battery cap.
3. Remove battery from night vision goggles.
4. Place battery in Arctic kit battery holder, recessed end (+ end) in first.
5. Screw the removed battery cap on Arctic battery holder.
6. Screw Arctic kit cap on night vision goggles.
7. Place Arctic kit battery holder in inside pocket next to body.
8. Keep spare batteries in inside pocket next to body.

F.4.6.2 Operation in Dusty or Sandy Areas

CAUTION

Operation in dusty or sandy areas can cause pitting and scratching of optical elements and damage to mechanical components unless the following precautions are observed.

1. Avoid pointing the night vision goggles into the wind unless necessary for operation.

2. Keep the carrying case closed unless removing or replacing items.

3. Ensure that all dust and sand are removed from the goggles after operation.

F.4.6.3 Operation in Rainy or Humid Conditions

CAUTION

Operation in rainy or humid conditions can cause corrosion and deterioration of the night vision goggles unless the following precautions are observed.

1. Install demisting shields.

2. Keep carrying case and storage case closed unless removing or replacing items.

3. Dry all parts after exposure to rain or high humidity.

4. Do not store night vision goggles in a wet carrying case or a wet storage case.

F.4.6.4 Operation in Salt Water Areas

CAUTION

Operation in salt water areas can cause corrosion of the goggles unless the following precautions are observed.

1. After exposure to salt water, clean with fresh water.

2. Unsnap the headstrap assembly and face cushion assembly and clean separately. Night vision goggles may be immersed in water. The face cushion assembly will normally air-dry in an hour.

3. Dry all parts completely. Do not disassemble.

4. Use lens tissue to clean the objective lenses and the eyepiece lenses.

F.5 AN/AVS-6 (ANVIS)

F.5.1 Background. The AN/PVS-5 NVGs did not fully satisfy the needs of aviators for conducting terrain flight at night. As a result, the ANVIS was deisgned to overcome or reduce the limitations of the AN/PVS-5 NVGs (Figure F-9). The ANVIS is a helmet-mounted light intensification device which enables operations to be conducted at terrain flight altitudes during low ambient light levels including overcast starlight.

F.5.2 Capabilities and Features. The ANVIS system consists of a shipping case containing one visor guard mount assembly and ANVIS carrying case. Figure F-10 identifies ANVIS components.

The ANVIS mounts directly to the standard flight helmet. A special mount and offset binocular is available for the AH-1 helmet-mounted sight.

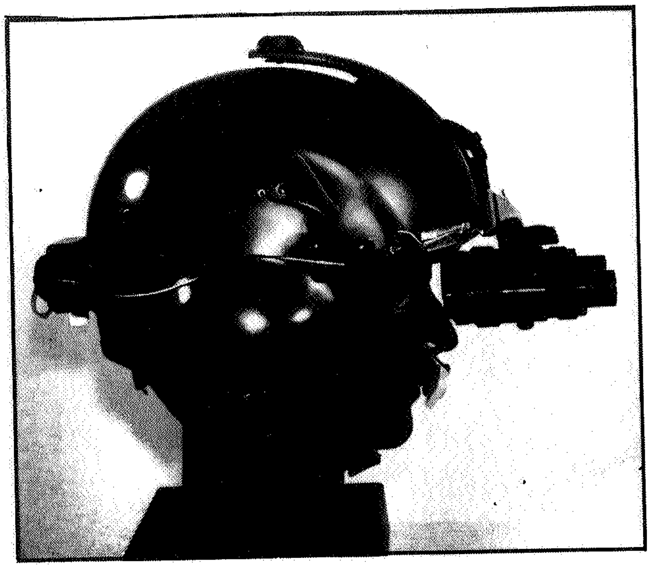


Figure F-9. Aviator's Night Vision Imaging System (ANVIS), AN/AVS-6

The ANVIS can be powered by a mercury or lithium battery or aircraft power.

ANVIS is stowable in a flipped-up position while on the helmet (Figure F-11).

A dim red glow between the binoculars and the aviator's field of vision indicates that battery power is less than 2.4 volts. The red glow indicates that 30 minutes of battery life remain.

F.5.3 Operational Characteristics of the ANVIS

1. Focal range — 254 mm (10 inches) to infinity
2. Depth perception — None
3. Magnification — Unity time 1
4. Visual acuity — 20/50
5. Crash loading — 10g nominal

Note

Rapid lateral movement of the head may cause the ANVIS to come out of the mount. A neckcord is provided to prevent dropping the system when this occurs.

6. Field of view — 40°
7. Operating temperatures — -32 °C to + 52 °C.

F.5.4 Daylight Training Filters. The ANVIS comes with two sets of filters. The filters are designed to provide a safe training environment and a good visual representation of the tactical aspect of ANVIS flying. One filter is placed over each objective lens. In addition to the filters, rubber eyecaps are placed around each eyepiece lens to minimize light.

CAUTION

To prevent damage to the image intensifier lens, the power pack should be turned off before changing daylight filters.

The image observed with daylight filters is a reverse of that present when using the ANVIS at night. The sky in daytime will be light, and a dark foreground will appear. At night, the sky is dark, and the foliage will appear light.

Images viewed through the filter will also have inconsistent shadow and contrast displays when compared with night viewing. Additionally, there will be an absence of night light displays or halo effect; i.e., buildings, cars, etc.

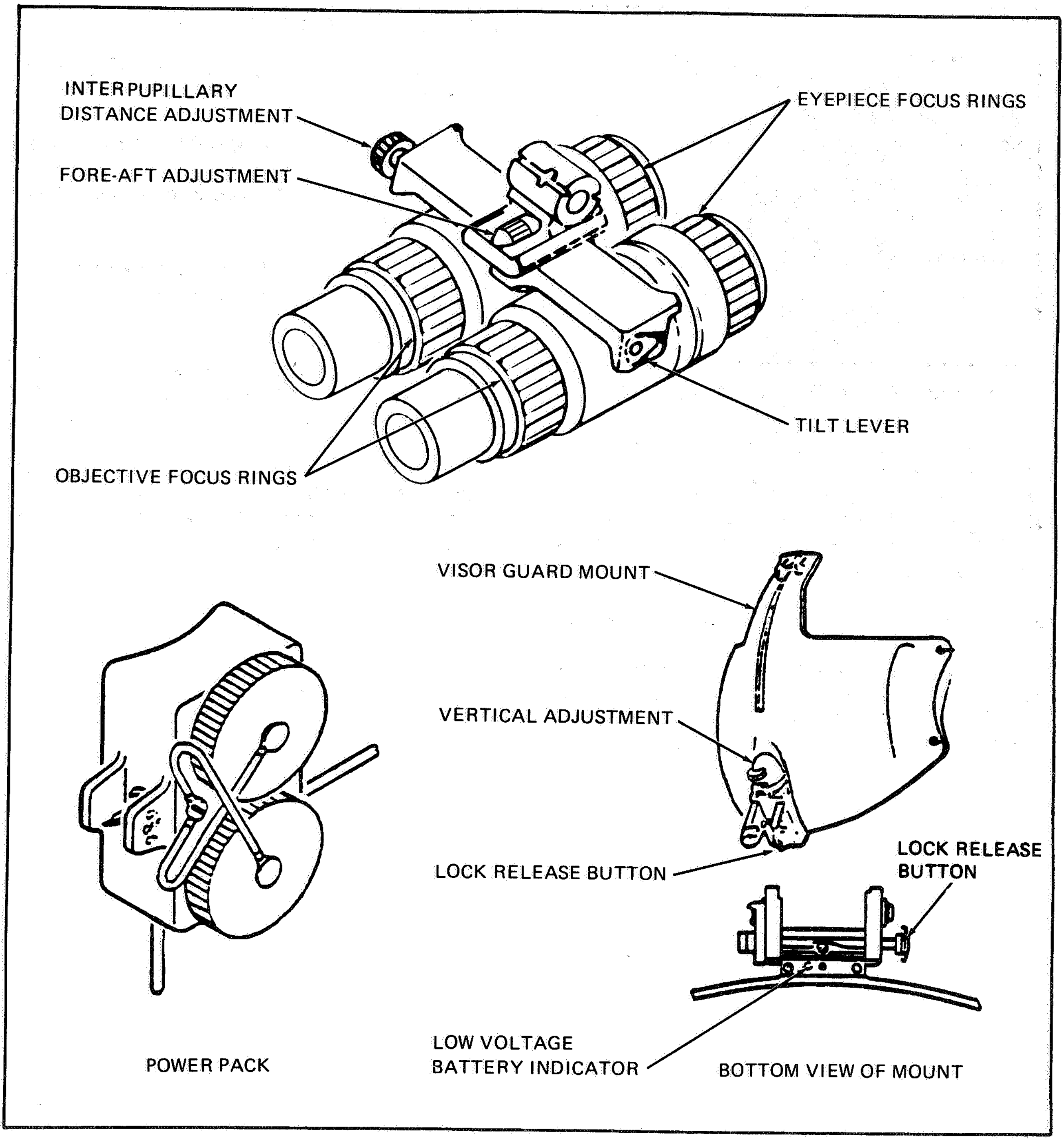


Figure F-10. ANVIS Components

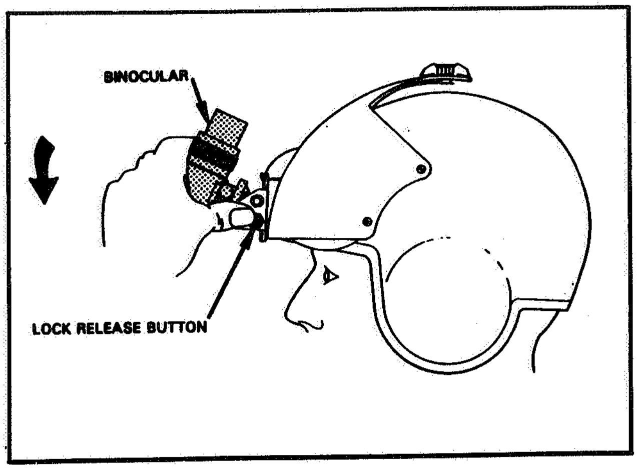


Figure F-11. ANVIS in Stowed Position

Flying in the daytime with the filtered goggles does not equal the psychological effects of flying at night, The need for night flying (with the goggles) will still exist. (The shortcomings of daylight filters will not allow ANVIS qualification to be conducted soley during daylight.)

F.5.5 Operation Under Unusual Conditions

F.5.5.1 Below Freezing. Adjustment knobs and levers on the ANVIS can be used with cold weather handgear. They should not be operated barehanded.

F.5.5.2 Dusty and Sandy Areas

1. The ANVIS should not be pointed into wind.
2. The carrying case should be kept closed.
3. Care should be taken in cleaning external surfaces.

F.5.5.3 Rainy or Humid Conditions. The ANVIS should be cleaned as necessary. It should not be stored in a wet case.

F.5.5.4 Salt Water Areas. The ANVIS should be cleaned with fresh water immediately after exposure to salt water (do not immerse).

F.5.5.5 NBC Equipment. ANVIS will be compatible with NBC equipment under development. It is not compatible with the M-24 gas mask presently in use.

APPENDIX G

Night Vision and Terrain Interpretation

G.1 INTRODUCTION

This appendix contains information concerning the physiological factors of night vision, dark adaptation considerations, night vision techniques, visual illusions and spatial orientation problems, and the techniques of terrain interpretation at night. The following information is a paraphrased abstraction of portions of the Department of the Army Training Circular 1-28 (TC 1-28), Rotary Wing Night Flight. It is presented in this manual to assist the helicopter pilot in developing his night flying skills by acquiring a comprehensive understanding of the problems of perception inherent in night tactical helicopter operations.

G.2 NIGHT VISION

Of all the sensory means that an aviator uses in flight, his eyes are the most important. He needs good depth perception for safe landings and takeoffs and good visual acuity for identifying terrain features and obstacles which lie along the flightpath. When flight is conducted during daylight hours, the eyes are capable of appreciating these visual cues; however, during hours of darkness, illumination is reduced and the unaided eyes are limited as to what can be seen. Flight personnel who have 20/20 day vision may not possess an adequate night vision capability. This may be caused by a physical deficiency or a self-imposed limitation (e.g., smoking). It is important that the aviator be aware of his deficiencies and limitations before conducting night flight. Avoidance of self-imposed limitations will assist the aviator in acheiveing good night vision.

Laboratory tests have proven that having an aviator with good night vision does not automatically guarantee the most effective use of this capability. An untrained aviator may find it difficult to identify an object at night; however, the eye, like the mind and hand, can be trained. Although the limits of night vision vary from person to person, experience shows that most aviators have never learned to use their night vision to its fullest capacity. An aviator with an average night vision capability who knows techniques of night vision is far better off than an aviator with superior night vision who doesn't know *how to see.*

G.2.1 Anatomy and Physiology of the Eye. The eye functions similar to a camera and consists of two main parts:

1. The cornea, lens, and iris combination gathers and controls the amount of light that is allowed to enter the retina.

2. The retina can be compared to a photographic film. It is a sensitive layer upon which the light is focused to form an image.

The visual center of the retina is called the fovea centralis. It contains only cones which operate most efficiently at ordinary illuminations such as those that prevail throughout the day and in normally lighted rooms at night. Cones provide for the perception of color and the ability for the normal individual to see clearly, sharply, and precisely with 20/20 or better visual acuity. Because the cones are more concentrated in the center of the retina, central vision is the most acute. As light levels are reduced, normal color vision becomes less reliable and finally disappears. Runway light colors can be identified because the light is of sufficient intensity for the cones to perceive color. If the color of an object or terrain feature is to be recognizable at night, it must be illuminated by a white light with sufficiently high intensity to permit cone perception of colors.

During darkness or with low-level illumination, central vision becomes less effective when a relative blind spot (5° to 10° wide) develops. As a result of the fovea's exclusive cone representation, the absolute blind spot is the 2° to 2.5° wide. However, since the area immediately around the fovea is predominated to cones, it too is relatively insensitive. Thus, the functional or operational blink spot affects an area from 5° to 10° wide to the center of the visual field. This results from the relatively light insensitive elements concentrated in the area immediately surrounding the retina of the fovea centralis. Since the central fields of vision for each eye are superimposed for binocular vision, we can speak of a single night blind spot for the normal man. The night blind spot should not be confused with the day blind spot. The day blind spot results from the optic disc's position on the retina. The optic disc is devoid of light sensitive receptors. However, because of the overlap of binocular vision, the day blind spot is not noticed. The night blind spot is centrally located. As a result, it is noticed even when both eyes are used. Each eye has an identical night blind spot so that viewing with one eye closed would produce the same limitation as binocular vision except that the day blind spot would also become apparent. If an object is viewed directly, it may not be detected because of the blind spot; if detected, it will fade more rapidly. As a result of the projected central blind spot, larger and larger targets will be missed with increasing distance. The use of the word *projected* is used figuratively in that the effect of the blind spot is as if it were being projected like a ray of blindness, obsuring larger areas with increasing distance from the viewer.

The remainder of the retina contains rods and cones with rods increasing in relative number toward the periphery. As previously stated, the central retina is capable of highly acute vision in high illumination due to the concentration of cones. This peripheral retina is almost exclusively associated with rods. Rods perceive only shades of gray. Because of the way they are connected to the brain, they only perceive form or shape; therefore, peripheral vision is less precise than central vision. However, rods are about 1,000 times as sensitive to light as cones. They are the primary visual receptor in dim illumination and thus mediate night vision. Greatest sensitivity of the rods is achieved after a total of 30 to 45 minutes. Exposure to light sources tends to bleach out the rods and reduces the night vision capability of the rods. Because visual acuity is reduced at night, object and target recognition is often limited to silhouette forms.

G.2.2 Dark Adaptation. Dark adaptation is the process by which the eyes increase their sensitivity to low levels of illumination. Rhodopsin (visual purple) is the substance in the rods responsible for light sensitivity. Dark adaptation occurs as the amount of visual purple in the rods increases through biochemical reactions. They may be accomplished to varying degrees and at different rates. In a darkened theater the eye adapts rather quickly to the prevailing level of illumination, which, compared to the characteristics of a moonless, starlit night, is rather high. Less time is required to adapt from the greater illumination level to complete darkness than from the high level of brightness in hangar interior. Thus, the lower the starting level of illumination, the more rapidly complete dark adaptation is achieved. Dark adaptation for optimum night visual acuity approaches its maximum level in approximately 30 to 45 minutes under minimal lighting conditions.

If the dark-adapted eye is carelessly or inadvertently exposed to a bright light while in flight, the sensitivity of that eye is temporarily impaired. The amount of impairment depends on the intensity and duration of the exposure. Brief flashing from a white (Xenon) strobe light of high intensity will have a minimum effect upon night vision because the pulses of energy are of such short duration (milliseconds); however, continuous exposure, particularly under undesirable conditions (haze, clouds), will cause a distraction that would reduce a pilot's ability to conduct night flight. Exposure to a flare or a searchlight beam which would normally be for a period in excess of 1 second could seriously impar the aviator's night vision. Depending upon the brightness and duration of such an exposure, the recovery of a previous maximum level of dark adaptation could take from 5 to the full 45 minutes in continued darkness.

Exposure to bright sunlight has a cumulative and adverse effect on dark adapation. This condition is intensified by reflective surfaces such as sand and snow. Aviators exposed to intense sunlight for 2 to 5 hours will experience a definite decrease in daylight visual sensitivity which can persist for as long as 5 hours. In addition, the rate of dark adaptation and the degree of night visual capacity will be decreased. These effects are cumulative and may persist for several days.

The retina rods are least affected by the wave length of a dark red light source (wavelength longer than 620 millimicrons). Because the rods are stimulated so slightly, night vision is not significantly impaired when viewing red lights of the proper wavelength. The intensity and duration of pre-exposure to this light source determines the degree to which night vision is affected.

G.2.3 Protection of Night Vision. Aviators who are required to conduct night missions should wear military neutral density sunglasses or equivalent filter lenses when exposed to bright sunlight. This precaution will minimize the rate of dark adaption at night and improve night visual sensitivity.

Red lights should be the only source of lighting in the cockpit. The intensity of the cockpit lights should be adjusted to the lowest level which will allow the pilot to interpret the instruments. Lights which are not mission essential may be extinguished.

Wearing approved red-lens goggles prior to the execution of a night operation allows the aviator to begin his dark adaptation in an artificially illuminated room and decreases the possibility of undesirable effects from accidental exposure to bright lights, especially when going from the briefing room to the flight line. The wearing of red-lens goggles, however, does not provide a good dark adaptation as does complete darkness for 30 to 45 minutes. When the mission permits, flight should be conducted in an area away from bright ground lights to allow sufficient time to achieve maximal dark adaptation prior to conducting an approach to minimal lights or low-level flight.

When conducting night operations from a fixed airfield, precaution should be taken to eliminate light sources which may impair the aircrew's dark adaptation. To ensure a better operating environment for an aircrew performing night missions, the following precautionary measures should be implemented:

1. Aircraft scheduled for night flight should be positioned on the airfield where the least amount of light exists.

2. Light discipline should be practiced by maintenance and service crews.

3. To permit taxi operations without bright lighting, taxi lanes cleared of obstacles should be established and marked with minimal lighting (preferably red).

4. Airfield lighting should be reduced to the lowest intensity.

5. Departure routes should be selected to avoid highways and residential areas where artificial illumination could reduce the aircrew's night vision.

During the conduct of a night tactical air mission, the aircrew can expect to experience battlefield and meteorological conditions (e.g., artillery flashes, flares, searchlights, lightning, etc.) which will cause total or partial loss of their night vision. When confronted with these conditions, the aircrew can apply the following techniques:

1. If a flash of high intensity light is expected from a specific direction, crewmembers should turn the helicopter to minimize exposure to the light source. When such a condition occurs unexpectedly and direct view cannot be avoided (e.g., lightning), dark adaptation can be preserved by covering or shutting one eye while using the other to observe. Once the light source is no longer a factor, the eye which was covered will provide the night vision capability required to conduct flight. This a possible because dark adaptation occurs independently in each eye.

CAUTION

Difficulty will be experienced with depth perception orientation outside the cockpit when viewing with the remaining dark-adapted eye, particularly when hovering near terrain obstacles or in the course of an approach to landing. Under such circumstances, altitude or distance should be maintained or increased until orientation is stabilized and assured.

2. Flight routes should be selected to avoid built-up areas where a heavy concentration of lights would be encountered. If these conditions are inadvertently encountered, the flight route should be altered to avoid overflight of the brightly illuminated area. Loss of dark adaptation from a single light source such as a farmhouse or an automobile can be avoided by turning the head and eyes away from the light.

3. When flares are being used to assist in a night tactical operation or if they are inadvertently detonated above your position, the helicopter should be flown as close to the periphery of the illuminated area as possible. Also, the pilot should maneuver the helicopter so that his position will be on the opposite side of the light source. The procedure prevents direct observation of the flare by the pilot.

4. Aircrews who are exposed to weapon flashes fired from the helicopter can avoid loss of night vision by limiting the duration of time during which the ordnance is expended. Ordnance can be fired in almost any combination without serious impairment of night vision so long as the weapon flash is of short duration and the aircrew avoids looking directly at the flash.

Night vision is dependent upon optimum function and sensitivity of the rods of the retina. Lack of oxygen to the rods (hypoxia) significantly reduces their sensitivity and causes an increase in the time required for dark adaptation and a decrease in the ability to see at night. Without supplemental oxygen a measurable decline in night vision is evident at all pressure altitudes in excess of 4,000 feet. For this reason, it is recommended that oxygen be used when operating above a pressure altitude of 4,000 feet (i.e., mountain operations where the mean elevations exceed 4,000 feet).

G.2.4 Self-Imposed Stresses. There are limitations to night vision which are self-imposed by aviation personnel. An awareness of these self-imposed restrictions is essential to ensure that each is avoided before participating in night flight.

G.2.4.1 Smoking and Night Vision. Cigarette smoking significantly increases the amount of carbon monoxide carried by the hemoglobin of red blood cells, thus reducing the blood's capacity to combine with oxygen. Hypoxia from carbon monoxide poisoning affects night visual sensitivity and dark adaptation in the identical way and to the same extent as hypoxia resulting from high altitude. Smoking three cigarettes in rapid succession or 20 to 30 cigarettes per day may saturate from 8 to 10 percent of the capacity of the hemoglobin of the red blood cells in the body. The physiological effect of this condition is that the smoker has effectively lost 20 percent of his night vision capability at sea level.

G.2.4.2 Alcohol and Night Vision. Alcohol has the effect of creating sedation, thus causing lack of coordination and impairment of judgment. As a resut, the aviator fails to apply the proper techniques of night vision. He begins to stare at objects and his scanning techniques become disorganized. Alcohol, like cigarette smoking, impairs night vision, but to a greater extent. The two in combination are probably cumulative. The degree to which night vision is affected is determined by the amount of alcohol consumed. Hangover after-effects will also impair visual scanning efficiency.

G.2.4.3 Fatigue and Night Vision. An aviator who is fatigued when performing night missions lacks mental alertness and fails to apply the proper techniques of night vision. He responds slowly to situations which require immediate reaction. He tends to concentrate his attention in one area without consideration for the total requirement. Depending on the degree of fatigue, his performance may become a safety hazard.

G.2.4.4 Sickness and Night Vision. Normally associated with sickness is an increased temperature and a feeling of unpleasantness. High body temperatures consume a higher rate of oxygen than is normally required. As a result, relative hypoxia is induced and degradation in night vision may occur. In addition, the unpleasant feeling that is associated with sickness distracts the aviator's attention and restricts his ability to concentrate on night flying requirements.

G.2.4.5 Nutrition and Night Vision. Failure to eat foods that provide sufficient vitamin A could cause impairment of night vision. Foods that are high in vitamin A content are eggs, butter, cheese, liver, apricots, peaches, carrots, squash, spinach, peas, and all types of greens. An adequate intake of vitamin A is normally provided by a balanced diet. Note that excess quantities of vitamin A will be of no additional help and may be harmful. Stomach contractions (hunger sensations) from missed or postponed meals appear to exert a most unpleasant effect and could conceivably cause distraction, breakdown in habit pattern, shortened attention span, and other psychological trait.

G.2.4.6 Physical Conditioning and Night Vision. Because of the physiological stresses of night flight, the aviator becomes more easily fatigued. To overcome this limitation, aircrew members should participate daily in a physical fitness maintenance program. Good physical fitness may help the aviator conduct night flight with less fatigue and might improve his night scanning efficiency.

G.2.5 Night Vision Techniques. Successful dark adaptation is only the first step toward maximizing one's ability to see at night. In order to see effectively in the dark, an individual must apply night vision techniques which enable him to overcome the previously discussed physiological limitations of the eyes. During daylight hours, objects can be perceived at a great distance with useful detail. At night the range is limited and detail is poor. A sound basic principle of visual scanning, day or night, is to view the predetermined field of vision moving the head and eyes together as a unit. Movement of the eyes, independent of the head — sideways of vertically — will in some cases reduce the protective overlap provided by a binocular vision or tend to break the stimuli that encourage fusion of the images reaching each eye. Thus, it prevents a tendency or condition in which the eyes might operate independently and cause confusion. Because of these limiting factors and the inability to perceive objects while rapidly sweeping a field of view, a systematic method of scanning must be used.

The technique used by the aviator to view the terrain along the flightpath becomes an important consideration if he is to perceive obstacles and identify terrain features which will ensure safety of flight, accurate navigation, and target acquisition. To scan effectively, the aviator must scan from side to side and from top to bottom of the field of view in 10° overlapping movements. This procedure is repeated continuously throughout the flight. While eye movements will be directed along the central visual axis, it is the peripheral field of vision that will permit detection of an object coming into the field of view. The scanning technique can be compared to a series of aerial photographs. All the pictures make up a composite of the terrain being viewed. Once the aviator has developed this scanning technique, he must incorporate one additional factor, the rate at which he will scan.

Because of the inability of the light sensitive elements of the retina to perceive images while in motion, the aviator must develop a stop-turn-stop-turn type motion. The time required in the stop portion of the scanning procedure is determined by the degree of detail that is required, but should be no longer than 2 to 3 seconds. This is because the rhodopsin (visual purple) in the rods will bleach out momentarily unless the stimulation is variable in light energy. (Remember that head movements must be limited during turning maneuvers to avoid vestibular illusions such as Coriolis, i.e., vertigo, spatial disorientation.)

Viewing an object using central vision during daylight poses no limitation; however, this same technique at night will result in a loss in the visual acquisition of the object. To compensate for this limitation, off-center vision must be used. This technique requires that an object be viewed by looking 10° above, below, or to either side rather than directly at the object. This allows the peripheral vision of the eyes to maintain surveillance of the object. The technique off-center vision applies only to surveillance of areas that are minimally illuminated or luminous. Under these conditions, cone vision is not stimulated. If an object or area is just bright enough to be seen by central vision (thus of sufficient intensity to stimulate the cones) and needs to be seen with considerable detail, then central vision is best used until the object begins to fade. At this point, the target should be redetected using off-center vision and retained until central vision recovers sufficiently to permit further observation.

Even though off-center vision is practiced, if an object is viewed for a period of time in excess of 2 to 3 seconds, the images tend to bleach out and become one solid tone. As a result, the object can no longer be seen, thus inducing a potentially unsafe operating condition. To overcome the limitation of night vision, the aviator must be aware of the phenomena and avoid viewing an object off-center longer than 2 or 3 seconds per scan. By shifting the eyes from one off-center point to another, the object will continue to be acquired in the peripheral field of vision.

Visual acuity will be significantly reduced at night. Because of this limitation, objects must be identified by their silhouettes. The ability of the aviator to recognize objects using this technique will be determined by the aviator's familiarity with the architectural design of the structures which are common to the area in which the mission is being flown. A sihouette of a building with a high roof and a steeple can be easily recognized as a church in America; however, churches in other parts of the world may have a low-pitched roof with no distinguishing features. Manmade features depicted on the map will also assist in recognition of silhouettes observed while in flight.

G.2.6 Depth Perception With Night Vision. The cues to depth perception are most apparent using central vision under good illumination. As night falls, judgment of depth perception decreases. One night-seeing eye is less precise as a distance measuring device and can be subject to illusions as well. A knowledge of the mechanisms and cues to depth perception will assist the aircrewman in making a better judgment of distance at night.

G.2.6.1 Estimation of Distance. There are numerous mechanisms and cues that can be used to judge distance. An estimation of distance in a situation can be derived by using only one mechanism or by using a combination of several mechanisms and cues. These estimations are usually derived on a subconscious level; that is, without the individual in a given situation looking for, or being aware of, additional cues beyond those which he would habitually use, and thus forming a more accurate estimation of distance. These cues to distance or depth perception are monocular or binocular. Monocular means that only one eye is required for judgment. The binocular cues depend on the slightly different view each eye has of the object. Consequently, binocular perception is of value only when the object is close enough to make a perceptible difference in the viewing angle of the two eyes.

In flying, most of the distances exterior to the cockpit are so great that the binocular cues are of little if any value. In addition, these cues operate on a more subconscious level than the monocular cues, and are thus not as capable of being improved by study and training. Therefore, binocular cues will not be discussed.

G.2.6.2 Depth Perception — Monocular Cues.

G.2.6.2.1 Geometric Perspective. An object has an apparent different shape, depending on the distance and angle from which it is being viewed. Types of geometric perspective are:

1. Linear Perspective. Parallel lines such as railroad tracks tend to converge as distance increases from the observer.

2. Apparent Foreshortening. The true shape of an object or terrain feature appears elliptical when viewed from a distance. As the distance to the object or terrain feature decreases, the apparent perspective changes to its true shape or form.

3. Vertical Position in the Field. Objects or terrain features which are farther away from the observer appear higher on the horizon than objects or terrain features that are closer to the observer.

G.2.6.2.2 Motion Parallax. This cue to depth perception is often considered the most important. Motion parallax refers to the apparent relative motion of stationary objects as an observer moves across the landscape. Near objects appear to move backward, past, or opposite the path of motion and far ones seem to move with it or remain fixed. When one fixes upon a near object, distant objects tend to move in the same direction as the observer. The rates of apparent movement depend on distance from the observer — objects near the aircraft move most rapidly, while distant objects appear to be almost stationary. Thus, objects that appear to be moving rapidly are judged to be near and those moving slowly are judged to be distant.

This can be readily appreciated from the reader's position if he looks at his surroundings. When the line of sight is fixed and maintained on one object while the position of the head is changing, other objects which appear to move in the same direction as the movement of the head are judged more distant while objects moving in the opposite direction are nearer than the object on which the line of sight is fixed.

While an individual drives along a road, the fence pickets near the roadside rapidly whiz by. A tree not far from the roadside passes more slowly. Mountains in the distance and the moon appear to be fixed or moving with the vehicle and its occupant.

G.2.6.2.3 Retinal Image Size. The size of an image focused on the retina is perceived by the brain to be of a given size. The nearer an object is to us, the larger is its retinal image. By experience, the brain learns to associate the distance of familiar objects by the size of their retinal image. A church building is seen at an unknown distance. It may be 30 to 40 feet tall. If its height subtends a small angle on the retina, the observer judges, usually subconsciously, that the building is at a great distance. A large angle would be judged by the observer as the building being close in to the helicopter. To utilize this cue, one must know the actual size of the object and have prior visual experience with it. If no experience exists, an object's distance would be determined primarily by motion parallax. If the retinal image size of an object increases, it is approaching or moving nearer; if it decreases, it is retreating or moving farther away; if constant, it is a fixed distance. Comparison of an object such as an airfield in the distance with an object of known size, configuration, and alignment such as a helicopter, will help to determine its relative size and apparent distance. Objects ordinarily associated together are judged to be at approximately the same distance. A helicopter is seen at a great distance making a slow turn. An airport is seen in approximately the same direction. The helicopter is judged to be in the traffic pattern and therefore at approximately the same distance to the field.

G.2.6.2.4 Overlapping of Contours or Interposition of Objects. When one object is seen to overlap another, the object which is being overlaped is farther away. Otherwise stated, an object partly concealed by another object is behind it.

G.2.6.2.5 Aerial Perspective. Colors or shades fade with distance. Large objects seen indistinctly are judged to have a considerable amount of haze, fog, or smoke intervening, and therefore appear to be at a great distance. If atmospheric transmission of light is less than expected, the distance is overestimated; if greater than expected, the distance is underestimated. A cargo helicopter is larger than an observation helicopter but, because of a difference in viewing distance and size, let's assume they both subtend the same angle on the observer's retina (their retinal images sizes are equal). Therefore, from this cue alone, assuming no previous experience with the appearances, they appear the same size. However, if the cargo helicopter is seen less distinctly because of visibility restrictions, it would be judged to be a greater distance away and larger than the observation helicopter.

As distance increases there is a loss of discrimination of texture. As one draws nearer to an object, more discrete detail become apparent; e.g., a green field develops blades of grass, a tree develops leaves and branches, and an animal becomes a steer rather than a cow. If a shadow is seen nearer the observer than an object, the object is nearer than the source of light.

G.2.7 Visual Illusions. With decreasing visual information, there is an increased probability of spatial disorientation. The cause for spatial disorientation due to the loss of visual reference may be a composite of several illusions. A few important visual illusions occurring in the aviation environment follow.

G.2.7.1 Autokinesis. Autokinesis, or the autokinetic illusion, is the illusory phenomenon of movement which a static light exhibits when started at for a long time in the dark. This phenomenon can be readily observed by taking a lighted cigarette into a completely dark room and staring at it until is appears to move. The apparent movement will begin after approximately 8 to 10 seconds. The cause is not known for certain, but appears to be related to the loss of surrounding structural references which normally serve to stabilize or anchor our visual perceptions. This illusion can be eliminated or reduced by visual scanning, by increasing the number of reference lights, or by continuously varying the light intensity. The most important of the three is visual scanning technique. A target of light or lights should be fixated for periods no longer than 10 seconds. A fixed object, such as an instrument panel top, should be used as a reference from which an observer may scan. This illusion is not exclusively limited to lights in darkness. It can occur whenever a small, bright, still object is stared at against a dull, dark, or nondescript background. Similarly, it can occur when viewing a small, dark, still object against a light, structureless environment. Place a pink-colored dot about 3 inches in diameter on a large chalkboard. Stare at the dot. Eventually it will move. Flying over still water toward a raft could produce such an illusion. Fixing on a marker in the snow day or night could produce similar results. Landing on an unlighted dark panel over an expanse of clay or dirt at night could cause the observer to experience autokinesis as well.

G.2.7.2 Confusion of Ground Lights With Stars. Many aviators have put their helicopters into very unusual attitude in order to keep some ground lights above them, having mistaken them for stars. Some aviators, for example, have misinterpreted the lights along the seashore as being the horizon, and maneuvered their helicopter dangerously close to the sea while under the impression of flying straight and level. Aviators have also confused certain geometric patterns of ground lights with a runway or identified ground lights as airborne targets.

G.2.7.3 Relative Motion. The illusion of relative motion is similar to a person sitting in a car at a railroad crossing waiting for a train to pass — though the train is actually moving, the person in the car has the sensation that he is moving. This is often encountered by the aviator during formation flying. He sees motion of his wingman or leader and interprets it as motion of his own. The only way to manage this illusion is for the aviator to have sufficient experience to understand that such illusions do occur and not to react to them on the controls.

G.2.7.4 Reversible Perspective Illusion. An aircraft may appear to be departing when it is in fact approaching. This illusion is often experienced when a visually acquired aircraft is turning toward or away from your path of flight. Part of this phenomenon may be due to relative motion.

G.2.7.5 False Horizons. The illusion of false horizons is experienced when an object other than the actual horizon is interpreted to be horizontal to the horizon. For example, a helicopter flying between two cloud banks may be flown in relationship to the lower cloud bank because the aviator feels that the lower cloud bank is horizontal to the horizon. In actuality the lower cloud may be at an angle to the horizon. The aviator tends to level the helicopter in reference to the cloud which puts the helicopter in a turn.

G.2.7.6 Altered Planes of Reference. The pilot of an aircraft approaching a line of mountains or clouds sees the illusion of a need to climb even though altitude is adequate to clear. The reverse is true when leaving such a line. In flying parallel to a line of clouds, there is a tendency to tilt away.

G.2.7.7 Depth Perception Illusion. Day and night flying over desert, snow, or water are characterized by a lack of adequate depth cues. This results in poor or diminished depth perception and, consequently, potentially dangerous situations. This is a special hazard to helicopter pilots during night autorotations. Flying into haze or fog at night can produce the same illusion of depth perception.

G.2.7.8 Flicker Vertigo. Much time and research have been devoted to the study of flicker vertigo. It has been demonstrated that a light flickering at a rate of between 4 and 20 cycles per second can produce unpleasant and dangerous reactions. These include nausea, vomiting, vertigo, and on rare occasions, convulsions and unconsciousness. Fatigue, frustration, and boredom tend to intensify these reactions. The problem can be caused by the flickering of the rotating beacons as reflected against an overcast sky.

G.2.7.9 Fascination (Fixation) In Flying. Fascination is said to occur when a pilot for one reason or another ignores orientation cues while his attention is focused on some other object or goal. Target hypnosis is a common type of fascination and is characterized by an incident that occurs when a pilot becomes so intent upon hitting his target during a gunnery run that he neglects to pull up in time to prevent crashing into the target.

G.2.7.10 Structural Illusions. Structural illusions are caused by heat waves, rain, snow, sleet, or other disturbances of the air media through which we see. For example, a straight line may appear curved as seen through the heat wave of the desert. As seen through slanting rain or sleet, a single wingtip light may appear to the pilot as a double light or in a different location.

G.2.7.11 Size-Distance Illusion. The size-distance illusion results from staring at a point of light which approaches and recedes from the observer. In the absence of additional distance cues, accurate depth perception is extremely difficult. Instead of seeing the light advancing or receding, the pilot has the illusion that it is expanding and contracting at a fixed distance from him. This illusion may also be dispelled by continually shifting the gaze.

G.2.8 Meteorological Conditions and Night Vision. Although a flight originates during conditions of clear skies and unrestricted visibility, meteorological conditions may deteriorate during flight. Because of the reduced vision at night, the gradual encounter of clouds can easily go undetected. During the initial buildup of cloud formations, difficulty will be encountered in detecting airborne objects due to the lack of contrast between the cloud and aircraft. Inadvertent entry into clouds may occur without warning. At low altitudes the encounter of ground fog and haze can be expected. The loss of visibility can be a gradual deterioration or a sudden encounter. Because detection of adverse weather is difficult at night, the aviator should maintain a constant awareness of changing conditions. The following conditions serve as indicators in the detection of adverse weather conditions at night:

1. A gradual reduction in the available ambient light will occur as cloud coverage increases, resulting in a loss visual acuity and contrast of terrain features.

2. Loss of visual contact with the moon and stars indicates that clouds are present. the degree to which the stars and moon are obscured determines the amount of cloud coverage.

3. Shadows caused by clouds obscuring the moon's illumination can be detected by observing the varying ambient light along the flight route.

4. The halo effect that is observed around artificial lights indicates the presence of moisture or other small particles. As the intensity of these lights decreases, the moisture or particle content increases.

5. The presence of water vapor suspended over water surfaces indicates that the temperature has reached the dew point and that this condition will spread over the ground area.

G.2.9 Principles of Night Vision. A thorough understanding of the anatomy of the eye and the techniques employed to overcome limitations are necessary in order to see in the dark. The principles that have been discussed in this appendix are summarized in the ten commandments of night vision:

1. Dark-adapt before attempting any night duties.

2. Avoid bright lights after dark adapting.

3. Identify objects by total form.

4. Practice blindfold cockpit drill.

5. Keep your windscreen clean, unscarred, and unscratched.

6. Use off-center vision when viewing an object.

7. Do not stare; scan constantly and systematically.

8. Use oxygen when conducting night flight above 4,000-feet MSL.

9. Avoid self-imposed stresses.

10. Keep physically fit.

G.3 TERRAIN INTERPRETATION

G.3.1 General. The ability of the aviator to see in the dark is dependent upon the ambient light level and how well he employs night vision techniques. Both factors are critical for good night vision; however, to effectively identify what is seen, the aviator must know the conditions which affect the visual presentation of natural and manmade features at night. The following paragraphs discuss the factors which affect terrain interpretation at night and the knowledge which must be acquired to compensate for these limiations.

G.3.2 Factors of Terrain Recognition. The likelihood of detecting a natural or manmade feature at night depends primarily on the following factors.

G.3.2.1 Night Vision Techniques. To see effectively during hours of darkness, night vision techniques must be learned and used when conducting night tactical air operations.

G.3.2.2 Ambient Light. Visual acuity improves as the ambient light level increases. Light sources may be natural (e.g., moon, stars) or artificial (e.g., flares, searchlights, cities). The use of artificial light can be on call or planned for a designated hour and minute. Natural light is a function of the moon phasing angle.

G.3.2.3 Object Size. Because visual acuity decreases at night, the ability of the eye to perceive objects that are small becomes difficult if not impossible. Large structures and terrain features such as churches, water towers, and rivers are more easily recognized during hours of darkness. A small object such as a tank would be difficult to identify because it becomes lost in its environment. To overcome this limitation, a longer viewing time and a shorter viewing distance is required.

G.3.2.4 Object Shape. A natural or manmade object can be identified at night by its shape or the silhouette it forms. Familiarization with the architectural design of buildings will assist in recognition of structures at night. Also, shape will assist in identifying objects that are difficult to recognize because of their small size. For example, a tank which could not be recognized because of its relative small size in relation to its environment may be easily recognized when viewed from the side because of its distinctive silhouette. Shape of terrain features also provides a means of identification at night. Open fields which are shown on the map as triangular shaped may provide positive identification when viewed from the helicopter. Landmarks such as a bend in the river or a prominent hilltop provide a distinct shape which aids in terrain interpretation at night.

G.3.2.5 Viewing Distance. Because the viewing angle becomes smaller as the distance from the object increases, objects which are large in size and distinctive in shape may become unrecognizable if viewed from a great distance at night. This, combined with poor depth perception at night, can lead to faulty judgment of size. Also, objects lose form as the viewing distance increases. A church building viewed at a close distance at night will appear as a large structure with a distinctive high roof; however, viewed at a great distance it may resemble a family dwelling. This phenomenon occurs when viewing military targets or terrain features at a great distance. The distance at which interpretation of an object becomes unreliable is also dependent upon the ambient light level. An object that might be identified by its shape and size at a distance of up to 1,500 meters during a high light condition might be unrecognizable at 500 meters during a low light condition.

G.3.2.6 Contrast. Identification of terrain features by contrast is dependent upon the available ambient light, the color and texture of the object being viewed, and its background.

The ambient light level will affect the degree of contrast that exists between objects. The higher the light level, the greater the contrast. This is because the reflectance is a constant percentage of illuminance. Therefore, as the illuminance level increases, contrast on absolute difference between objects increases. Each object possesses a different reflectance due to the nature of its reflective surface. As the ambient light increases, more light is reflected, causing a shade change. Objects with a poor reflective surface appear black during low light levels and a dark gray during a high light level. Objects or terrain features which possess good reflective quality will appear a much lighter gray under all conditions of ambient light.

The color and texture of an object or terrain feature will affect its reflective quality. This characteristic of an object of terrain feature will aid or detract in identification by contrast. An open field with no vegetation growth which is light in color is an example of an optimum reflective surface. Areas which are covered with dense vegetation provide the worst condition of reflectivity. Seldom is terrain encountered where the extreme of both cases will be found. Knowledge of the reflective quality of objects and terrain features will aid in identification by contrast. Objects and terrain features which are most affected by contrast are as follows.

G.3.2.6.1 Roads. Dirt roads provides excellent contrast between the surrounding terrain and its surface. This is more pronounced where the road is cut through heavily forested areas. Normlly, a dirt road will vary in soil texture and color from that of the soil adjacent to the road. This condition further improves the contrast of the dirt road and surrounding terrain. Asphalt roads are difficult to identify because the dark surface reflects very little light which reduces the contrast between the road and surrounding terrain. Concrete highways provide an excellent reflective surface and can be easily identified at night.

G.3.2.6.2 Water. Bodies of water provide very little contrast against a landmass during low light conditions. When viewed from the air, lakes or rivers appear as dark gray in color. As the light level increases, water begins to change in color, contrast increases, and reflected moonlight can be easily detected. When a surface wind exists, the reflection off the water is intensified by the ripples on the surface which further aid in identification. Bodies of water are more easily recognized when viewed from an angle rather than directly overhead.

G.3.2.6.3 Open Fields. Contrast is very poor in cultivated fields. Most crops are of dark color and tend to absorb light. During the harvest or dormant time of the year, the color of the vegetation changes to a lighter color and contrast improves. A recently plowed field may be void of vegetation; however, because of the coarse texture of the soil which is caused by plowing, light is absorbed and very little is reflected.

G.3.2.6.4 Forested Areas. Heavily forested areas do not reflect light and appear as dark areas at night. Excellent contrast exists between an open field and a forested area that normally surrounds an open field. Difficulty will be experienced in identifying objects and terrain features because of the lack of contrast.

G.3.2.6.5 Desert. The light color of the soil and sparse vegetation growth which is characteristic of desert terrain provide the best condition of detecting objects and prominent terrain features by contrast. Military targets are easily recognized on the desert because of the contrast between dark and light objects. Frequently, camouflage is used to avoid detection. Mountain ranges which abruptly rise from the desert floor can be easily identified because of the dark color of barren mountains as contrasted against the light color of the flat terrain.

G.3.3 Effects of Ambient Light. Reduced light level at night decreases visual acuity which restricts the range at which an object can be identified. Terrain interpretation by size, shape, and contrast becomes difficult. Because of these limitations, flight must be conducted at slow airspeeds. Safety of flight becomes an important consideration. As a result, flight during low ambient light conditions without night vision devices will be conducted at fixed altitudes which ensure adequate terrain and obstacle clearance.

A high light condition improves visual acuity which increases the range at which an object or terrain feature can be identified. Terrain interpretation by size, shape, and contrast becomes very effective. Because obstacles are more easily recognizable and navigation is easier, faster airspeeds can be flown at lower altitudes.

G.3.4 Effects of Flight Altitude

G.3.4.1 High Atitude. When flight is conducted above 100 feet at night, discriminability of objects on the ground progressively decreases as altitude increases. This condition is affected by all levels of ambient light. Contrast between objects becomes less distinguishable and tends to blend together as altitude increases. Terrain definition becomes less recognizable at higher altitudes which increases the difficulty in detecting altitude changes. Distortion of the form of objects becomes apparent because of the change in viewing angle and the distance at which the object is being viewed. All of these conditions increase the difficulty in conducting pilotage navigation.

G.3.4.2 Low Altitude. Discrimination of ground objects increases as the helicopter is flown closer to the ground. In addition, terrain definition and contrast are improved. This allows for better recognition of objects and terrain features which improves the navigational capability of the aircrews. Recognition of terrain features by silhouetting an object against the skyline is an effective means of identification which cannot be used at high altitude. The visual perspective changes in that the area which can be viewed is smaller. The apparent rate of speed increases, which reduces viewing time. Airspeed may have to be reduced to permit more accurate terrain interpretation.

G.3.5 Effects of Moon Altitude

G.3.5.1 Low Altitude. During all phases of the moon when its altitude is low, ambient light is reduced. The light level is further reduced in valleys and on the backside of mountains by the shadows that occur. When low level flight is conducted toward the moon during high light levels, extreme glare will be experienced. This condition will cause distortion of vision and possible loss of dark adaptation. Recognition of objects or terrain features that are visible along the skyline is improved. Because the shadow cast by an object distorts its true perspective, difficulty in recognizing objects by their form will be experienced.

G.3.5.2 High Altitude. The higher the altitude of the moon, the greater the ambient light level improves visual acuity and contrast. Shadows which cause distortion of objects and terrain features and loss of ambient light do not occur. The best conditions for terrain interpretation for any phase of the moon exist when the moon is at its highest altitude.

G.3.6 Visibility Restriction. During conditions of reduced visibility, the ambient light level is reduced, causing a loss of visual acuity. The onset of visibility restrictions will normally be gradual. Initially, the visual range at which an object or a terrain feature can be identified is reduced, followed by a loss of terrain definition. As visibility becomes more restrictive, night vision may become impaired to the extent that low level flight should be discontinued.

Normally, ground visibility restriction (e.g., fog, haze) can be avoided when flight is conducted above 500 feet. If visibility restrictions are encountered above this altitude, flight should be conducted by reference to instruments.

G.3.7 Effects of Terrain

G.3.7.1 Desert. Because of the lack of recognizable terrain features and vegetation growth, navigation is difficult over desert terrain. The texture and color of the soil provides for optimum reflectivity of ambient light and identification of objects by contrast. Desert terrain which includes barren mountain ranges provides more recognizable terrain features because of rapid changes in elevation.

G.3.7.2 Rolling Terrain (Heavy Vegetation). Because of the lack of recognizable terrain features, terrain interpretation is difficult. Contrast is good between forested areas and open fields. Rivers and terrain features, which give distinct changes in elevation from surrounding terrain, provide the most recognizable natural landmarks for navigation. Dirt roads and farm structures provide the most distinguishable manmade features. Airspeed will normally be slower to improve terrain interpretation. Flight altitude should be as low as terrain obstacles will allow; however, during periods of low ambient light, reduced visual acuity restricts obstacle identification and the flight altitude will normally be higher.

G.3.7.3 Mountains. Terrain identification can be accomplished best where rapid changes in elevation occur (e.g., mountainous areas), silhouetting ridgelines or other objects with vertical features. Decreased ambient light can be anticipated in valleys and on the backside of mountains when the moon is low on the horizon. Contrast is poor because of the heavy growth of vegetation and the dark color of the earth that is common to mountain regions. During high light conditions, navigation is made easier by the abundance of recognizable terrain features; however, airspeed will normally be lower in mountanious regions because of rapidly changing terrain which requires corresponding altitude changes.

G.3.8 Effects of Seasons (Winter)

G.3.8.1 Contrast. Contrast improves during the winter because fewer open fields are cultivated, thus resulting in a change of color and texture of farm areas. Contrast is also improved when snows covers the ground. The light color of the snow, compared with structure and heavy forested areas, enhances terrain interpretations.

G.3.8.2 Foliage. The loss of foliage of deciduous trees and plants during the winter improves interpretation of terrain features. When heavy growths of these trees and plants cover small rivers and streams, identification of these and other terrain features can be made more easily. Plants and grass which cover open fields change in color and improve the contrast between open fields and evergreens. In areas where plant and tree growth is predominantly deciduous, contrast will be reduced and the difficultly of terrain identification increased. Because a tree is barren of foliage, less light is reflected and the difficulty in identifying obstacles when flight is conducted in low level is increased. This condition induces a safety hazard and may require that the helicopter be flown at a higher altitude.

G.3.8.3 Ambient Light. The orbital path of the moon is closer to the earth during the winter. At this time, ambient light level is higher than at any other time of the year. This improves visual acuity, which enhances terrain interpretation.

G.3.8.4 Meteorological Conditions. It can be anticipated that during the winter there will be an increased number of days when cloud coverage and restricted visibility will prevail. Both conditions significantly reduce the available ambient light which has the effect of decreasing visual acuity and increasing the problem of terrain interpretation.

G.3.8.5 Visual Observation. Where conditions of extreme cold and heavy buildup of snow exist, manmade and natural terrain features may be hidden. A road intersection which provides a good navigation checkpoint may be obscured by a snow drift. Identification cannot be made by visual observation, but association with other objects or terrain features must be made. A power line, fence line, or a cut through a forested area must be used to locate the road intersection. Small rivers and lakes that are indicated on the map may be frozen and covered with snow and may not be recognizable. Positive identification can only be made by associating the relative position with other terrain features such as a depression, a tree line, or any other distinguishable terrain features.

G.3.9 Effects of Seasons (Summer)

G.3.9.1 Contrast. During the summer, identification of objects and terrain features by contrast is less effective as compared to the winter season. This is caused by the increased amount of cultivation of open fields and a new growth of foliage on deciduous trees and plants.

G.3.9.2 Foliage. Because of the dense foliage that obscures small rivers and streams, these terrain features will be difficult to recognize. Military targets will also become unrecognizable when located in or near forested areas.

APPENDIX H

Ordnance Delivery Charts

H.1 INTRODUCTION

The charts presented in this appendix are provided to aid in preflight and inflight determination of mil settings. Through the use of these charts, the pilot/gunner can determine, when range is known, the proper mil setting to set in the pilot's sight (or attitude indicator pitch angle) for the type delivery and ordnance being utilized.

H.2 CHART USAGE

1. Select the appropriate chart for:

   (a) Type of fire (running, hover)

   (b) Altitude and airspeed

   (c) Weapon (2.75 inch, 5.00 inch)

2. Determine the altitude of the target above or below the aircraft's altitude and enter the chart on the left-hand side.

3. Determine the range to the target and enter the bottom scale.

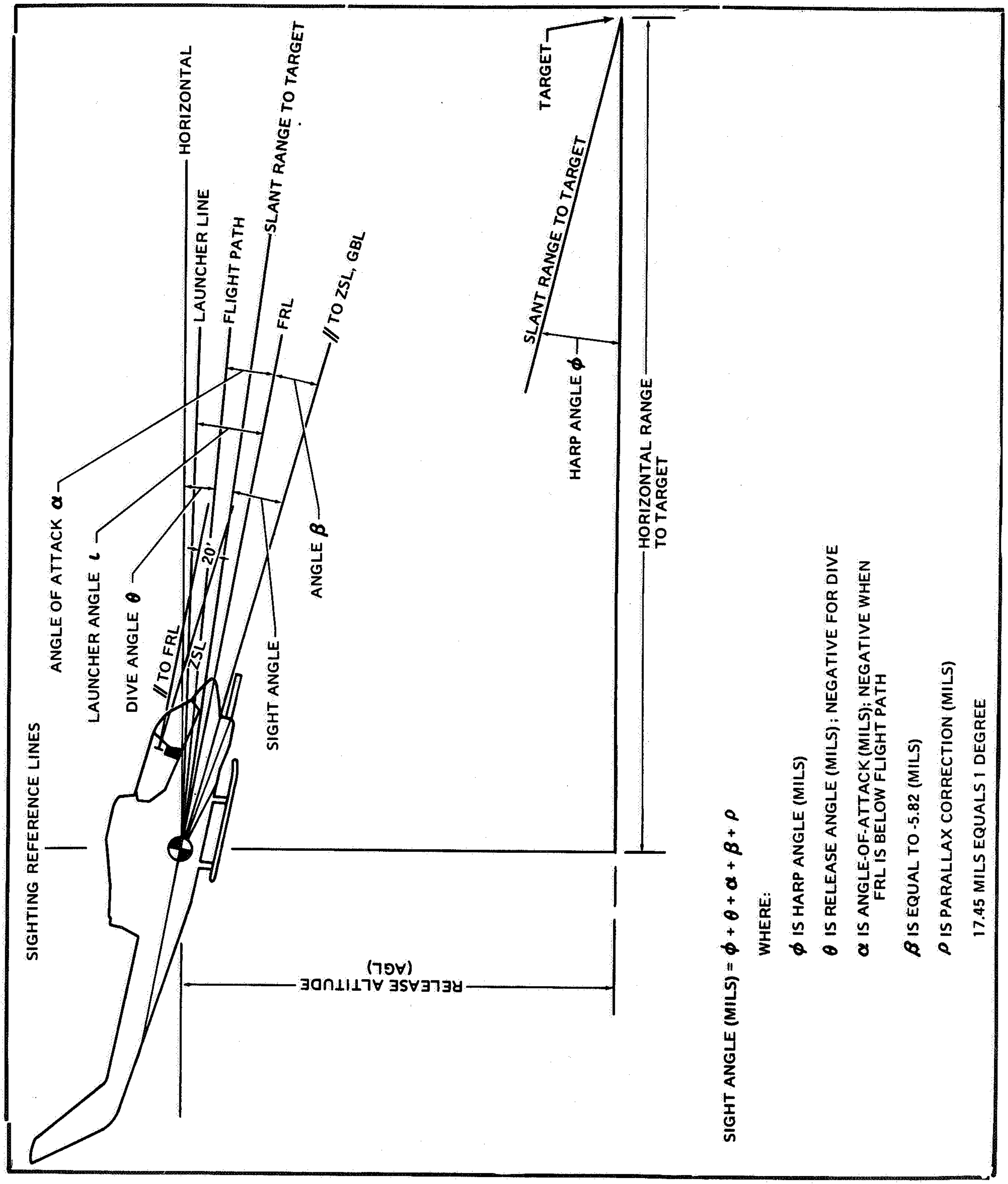
4. The intersection of the two lines will determine the correct firing data.

   (a) If the intersection is on one of the trajectory arcs, the mil setting/attitude indicator data as written will be utilized.

   (b) If the intersection takes place between two arcs, interpolation is required.

Note

- The attitude indicator data is based on the indicator being set on zero while on level ground.
- The numbers across the top arc with dotted lines represent weapon time of flight in seconds.



SIGHT ANGLE (MILS) = $\phi + \theta + \alpha + \beta + \rho$

WHERE:

ϕ IS HARP ANGLE (MILS)

θ IS RELEASE ANGLE (MILS); NEGATIVE FOR DIVE

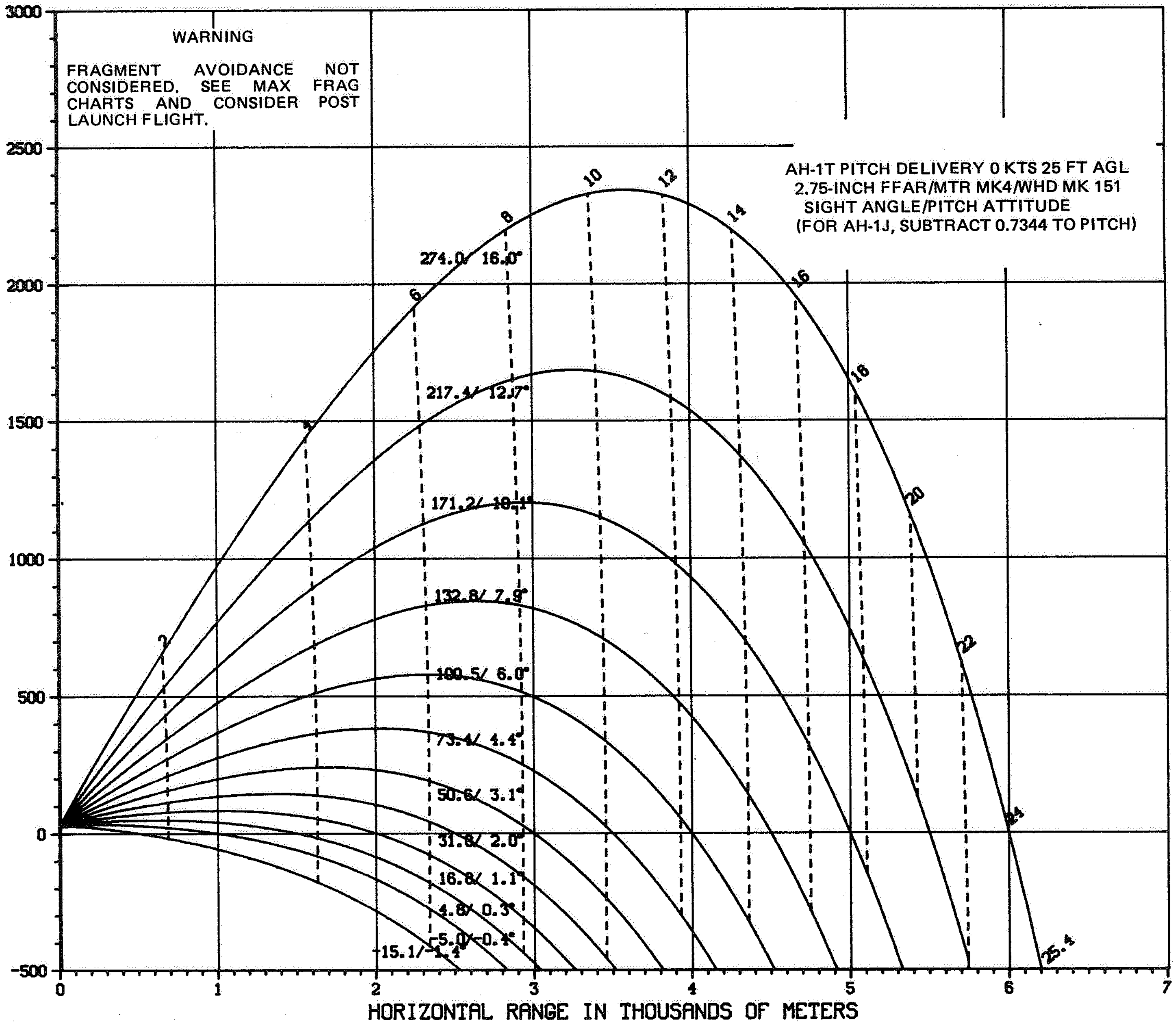
α IS ANGLE-OF-ATTACK (MILS); NEGATIVE WHEN FRL IS BELOW FLIGHT PATH

β IS EQUAL TO -5.82 (MILS)

ρ IS PARALLAX CORRECTION (MILS)

17.45 MILS EQUALS 1 DEGREE

Figure H-1. Sighting Reference Lines



WARNING

FRAGMENT AVOIDANCE NOT CONSIDERED. SEE MAX FRAG CHARTS AND CONSIDER POST LAUNCH FLIGHT.

AH-1T PITCH DELIVERY 0 KTS 25 FT AGL
2.75-INCH FFAR/MTR MK4/WHD MK 151
SIGHT ANGLE/PITCH ATTITUDE
(FOR AH-1J, SUBTRACT 0.7344 TO PITCH)

Figure H-2. 2.75-Inch FFAR Pitch Delivery (Sheet 1 of 6)

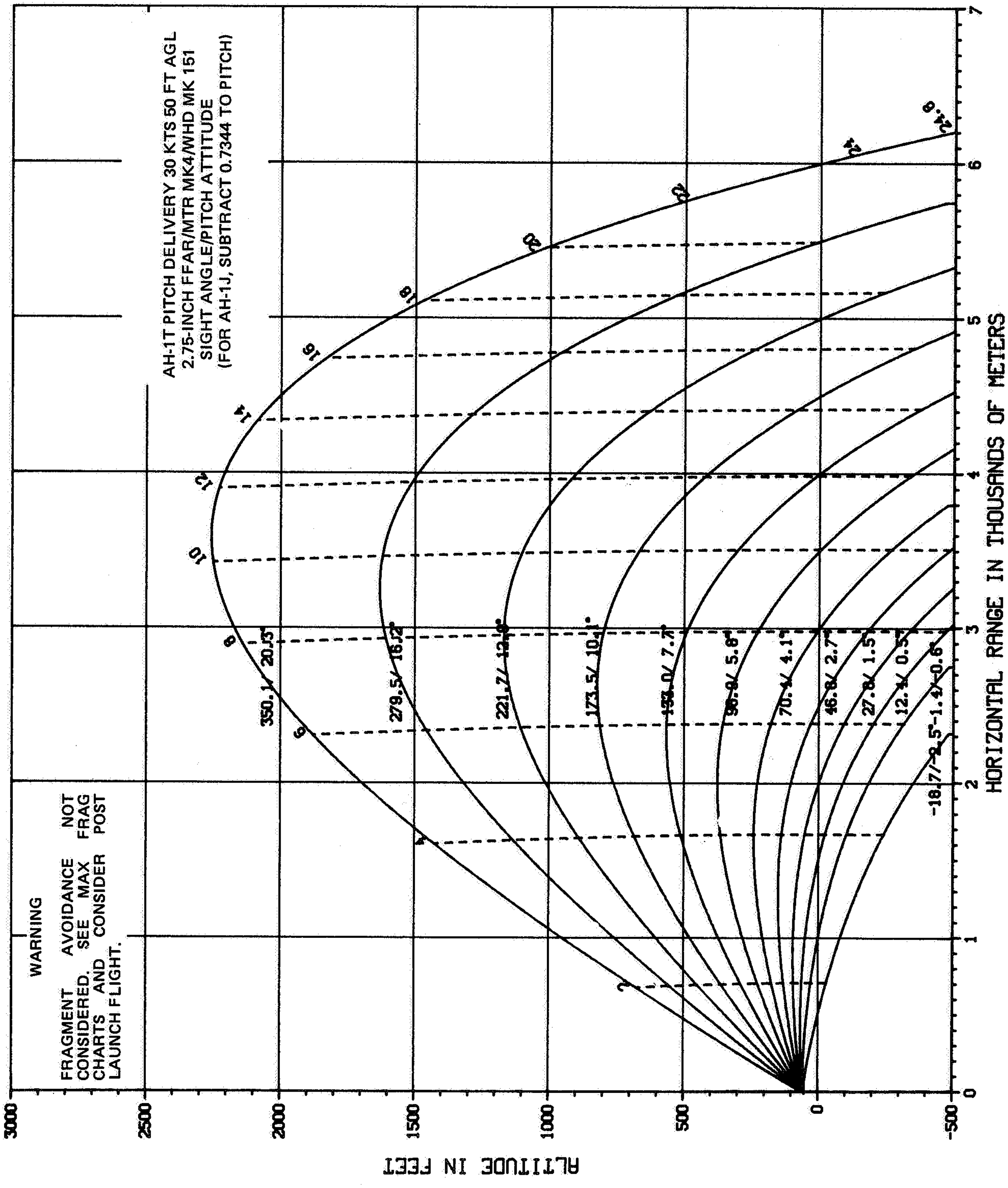
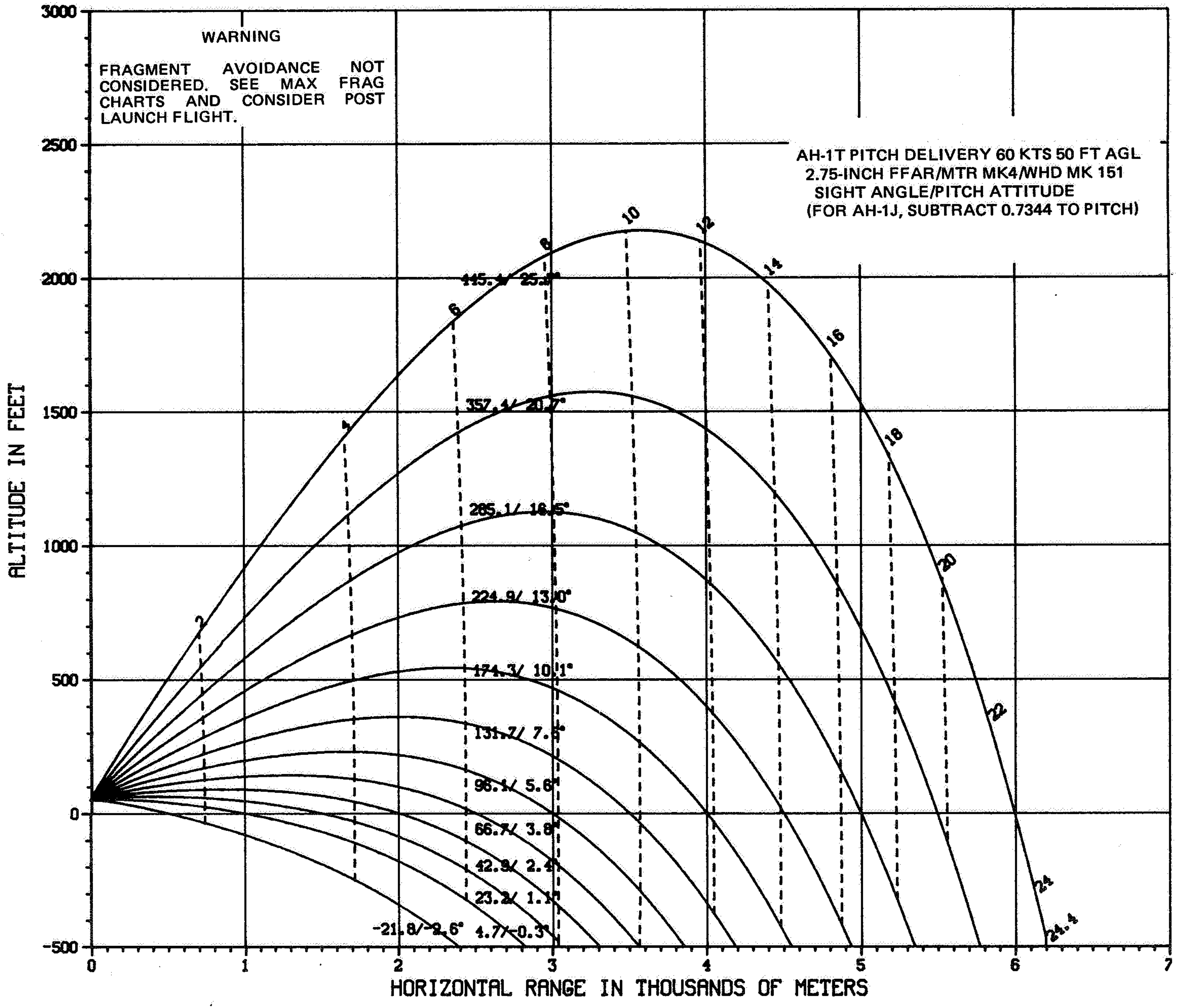


Figure H-2. 2.75-Inch FFAR Pitch Delivery (Sheet 2 of 6)

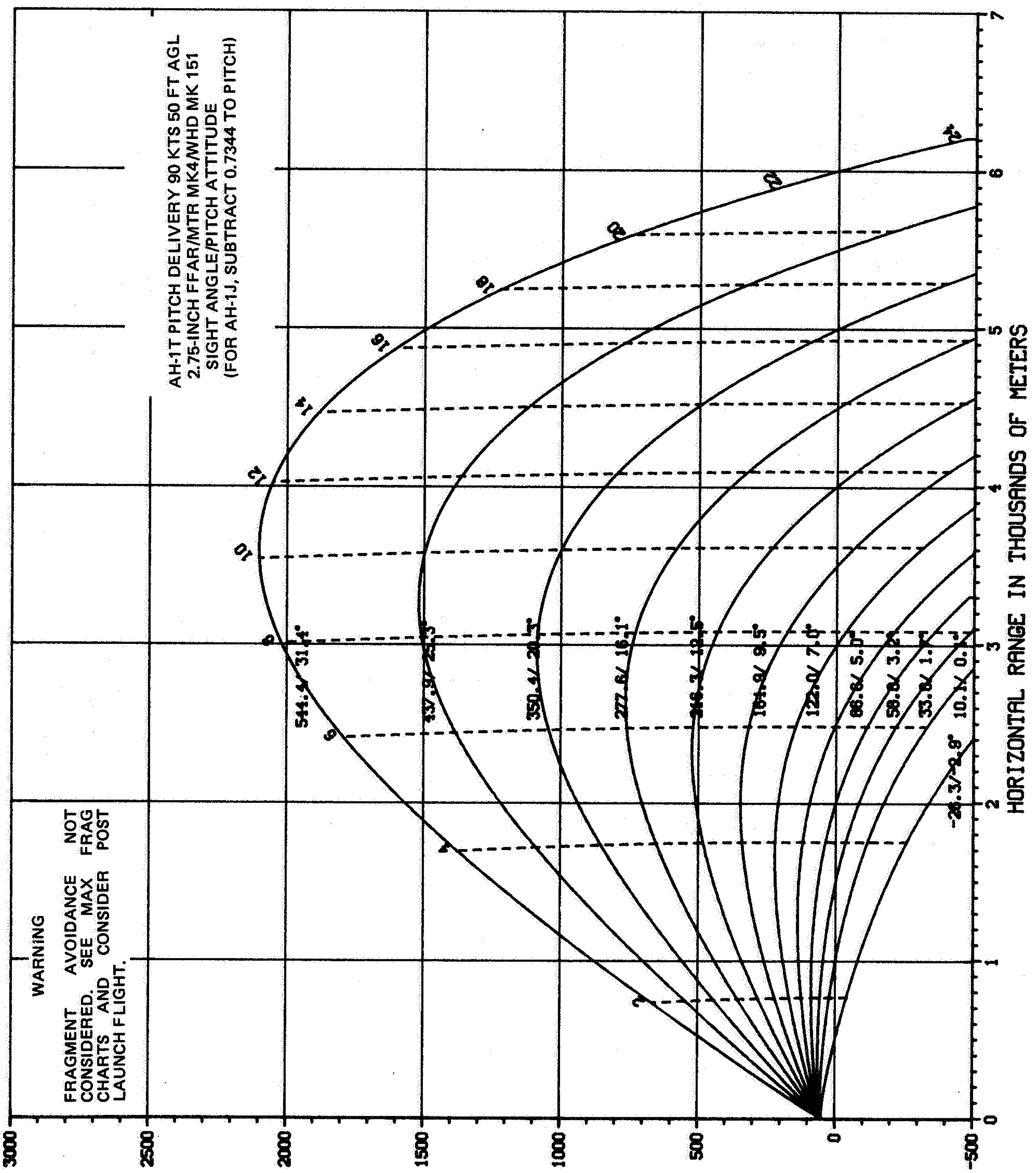


WARNING

FRAGMENT AVOIDANCE NOT CONSIDERED. SEE MAX FRAG CHARTS AND CONSIDER POST LAUNCH FLIGHT.

AH-1T PITCH DELIVERY 60 KTS 50 FT AGL
2.75-INCH FFAR/MTR MK4/WHD MK 151
SIGHT ANGLE/PITCH ATTITUDE
(FOR AH-1J, SUBTRACT 0.7344 TO PITCH)

Figure H-2. 2.75-Inch FFAR Pitch Delivery (Sheet 3 of 6)



AH-1T PITCH DELIVERY 90 KTS 50 FT AGL
2.75-INCH FFAR/MTR MK4/WHD MK 151
SIGHT ANGLE/PITCH ATTITUDE
(FOR AH-1J, SUBTRACT 0.7344 TO PITCH)

WARNING

FRAGMENT AVOIDANCE NOT CONSIDERED. SEE MAX FRAG CHARTS AND CONSIDER POST LAUNCH FLIGHT.

Figure H-2. 2.75-Inch FFAR Pitch Delivery (Sheet 4 of 6)

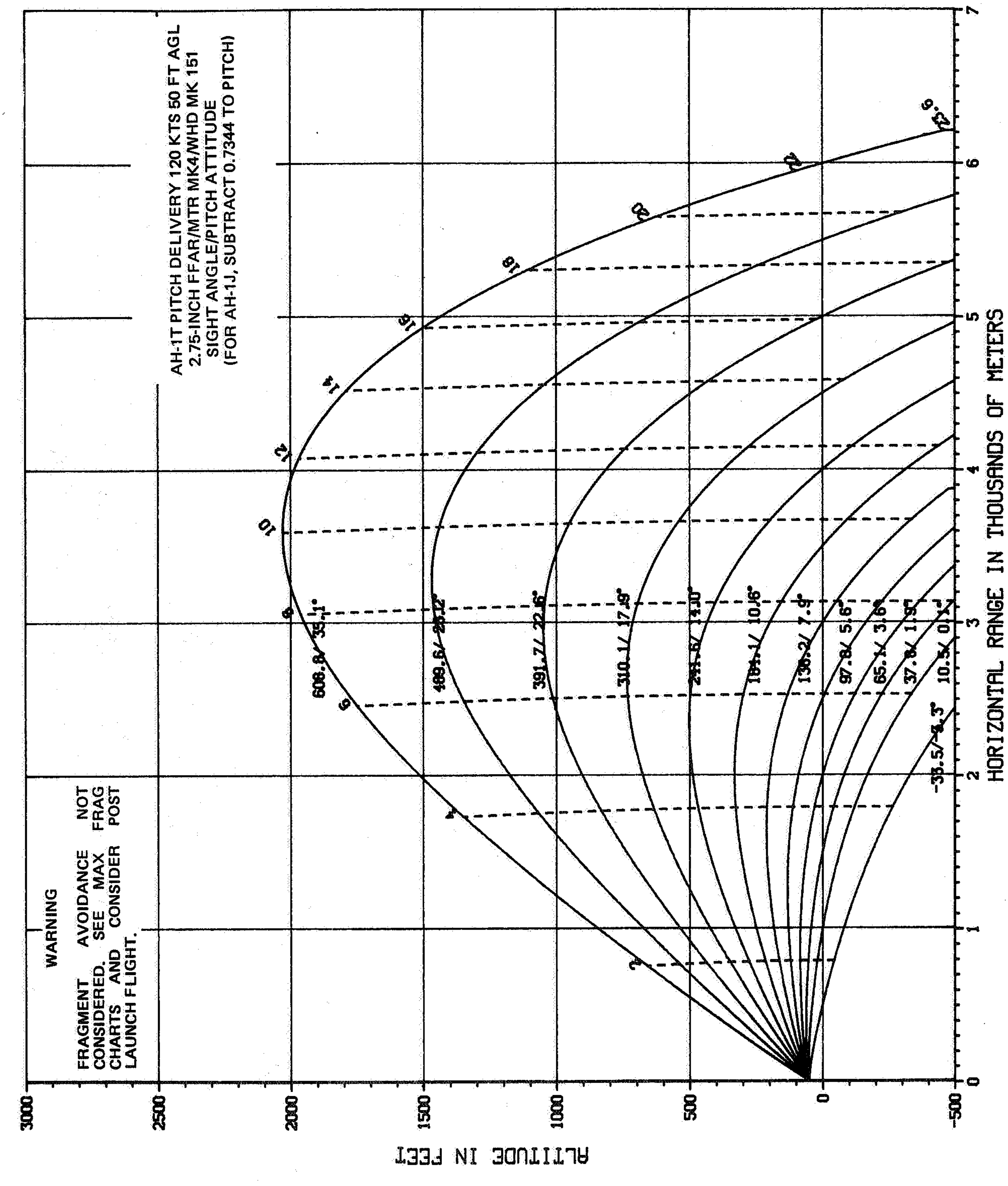


Figure H-2. 2.75-Inch FFAR Pitch Delivery (Sheet 5 of 6)

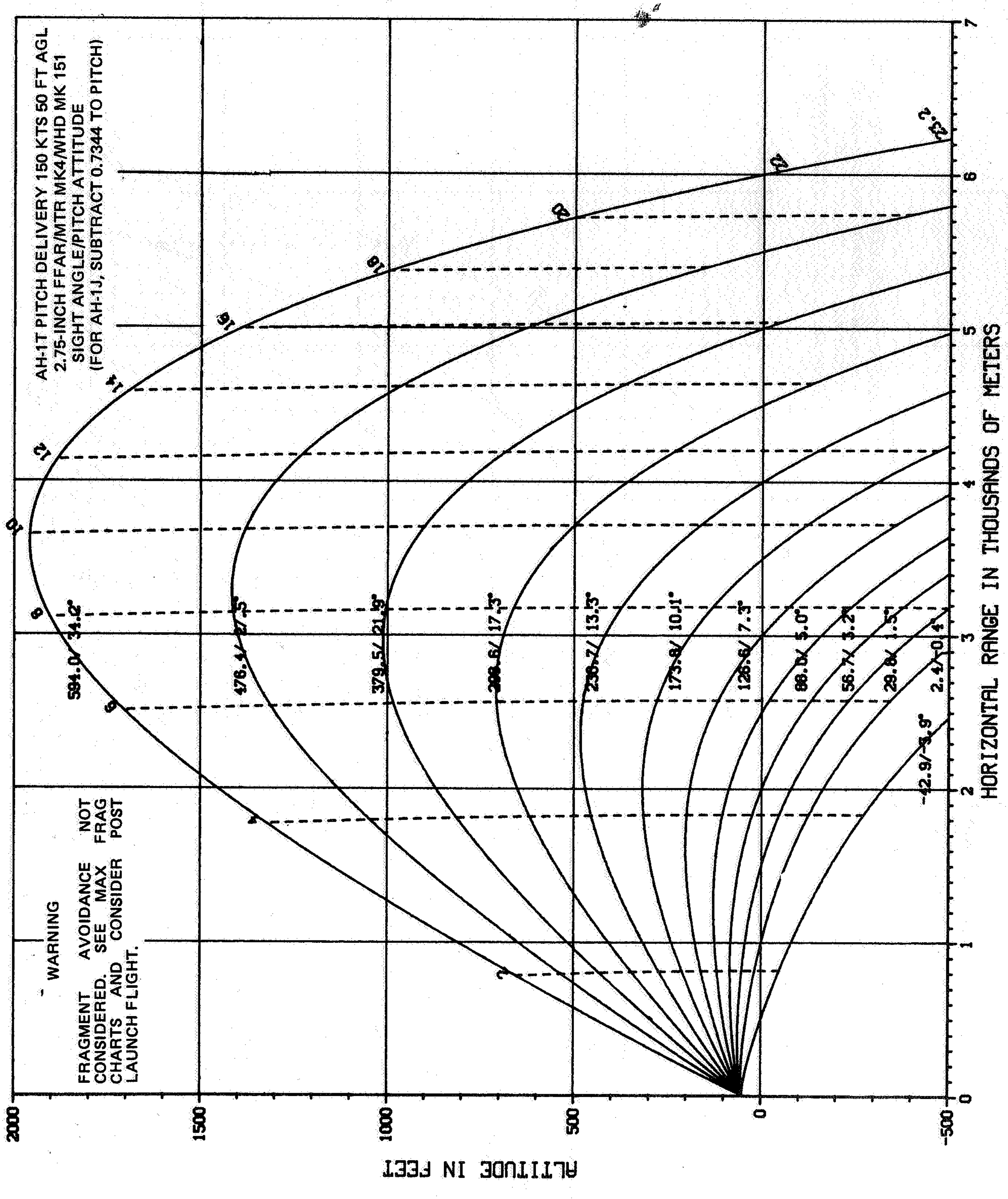


Figure H-2. 2.75-Inch FFAR Pitch Delivery (Sheet 6 of 6)

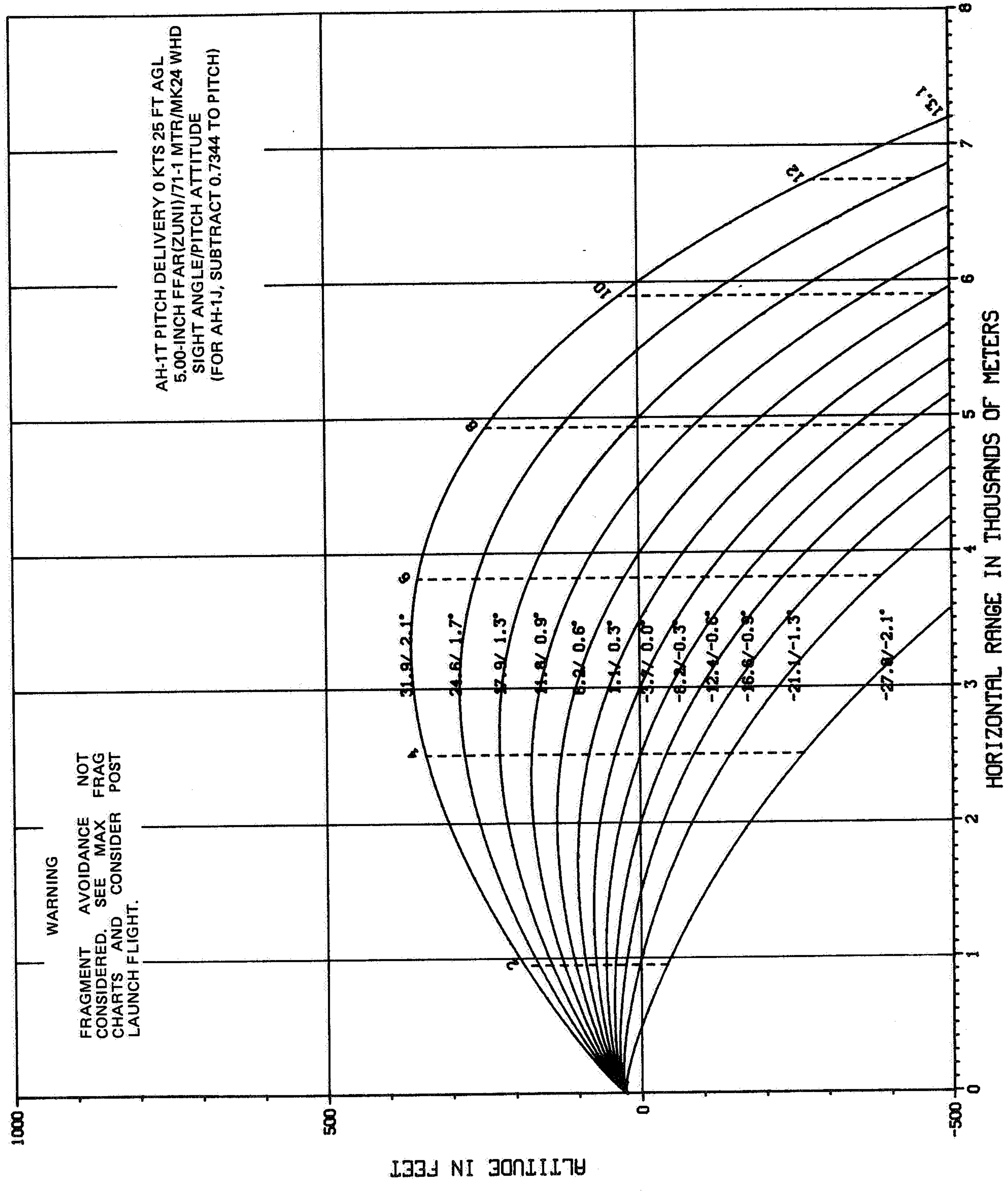
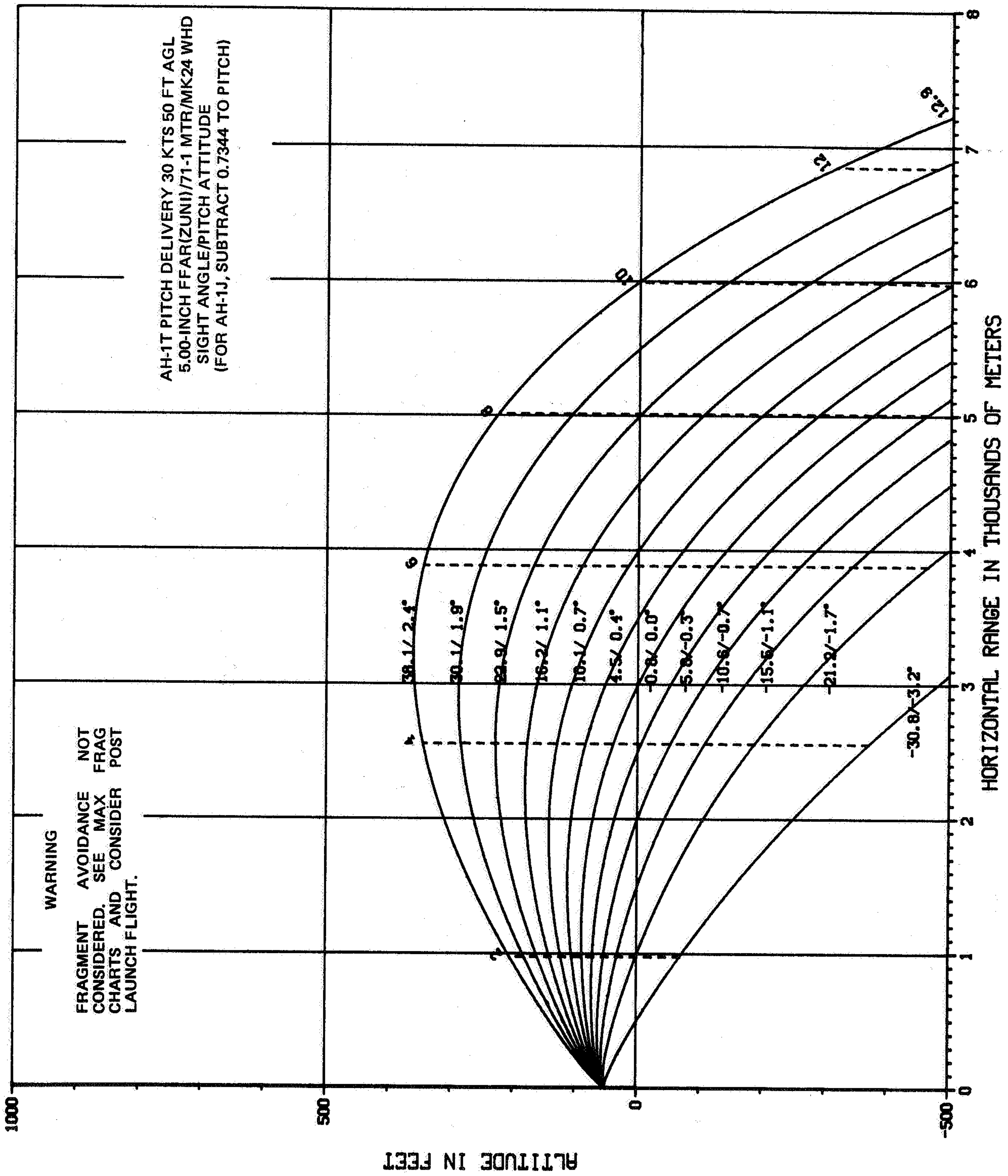


Figure H-3. 5-Inch FFAR Pitch Delivery (Sheet 1 of 6)



AH-1T PITCH DELIVERY 30 KTS 50 FT AGL
5.00-INCH FFAR(ZUNI)/71-1 MTR/MK24 WHD
SIGHT ANGLE/PITCH ATTITUDE
(FOR AH-1J, SUBTRACT 0.7344 TO PITCH)

WARNING

FRAGMENT AVOIDANCE NOT CONSIDERED. SEE MAX FRAG CHARTS AND CONSIDER POST LAUNCH FLIGHT.

Figure H-3. 5-Inch FFAR Pitch Delivery (Sheet 2 of 6)

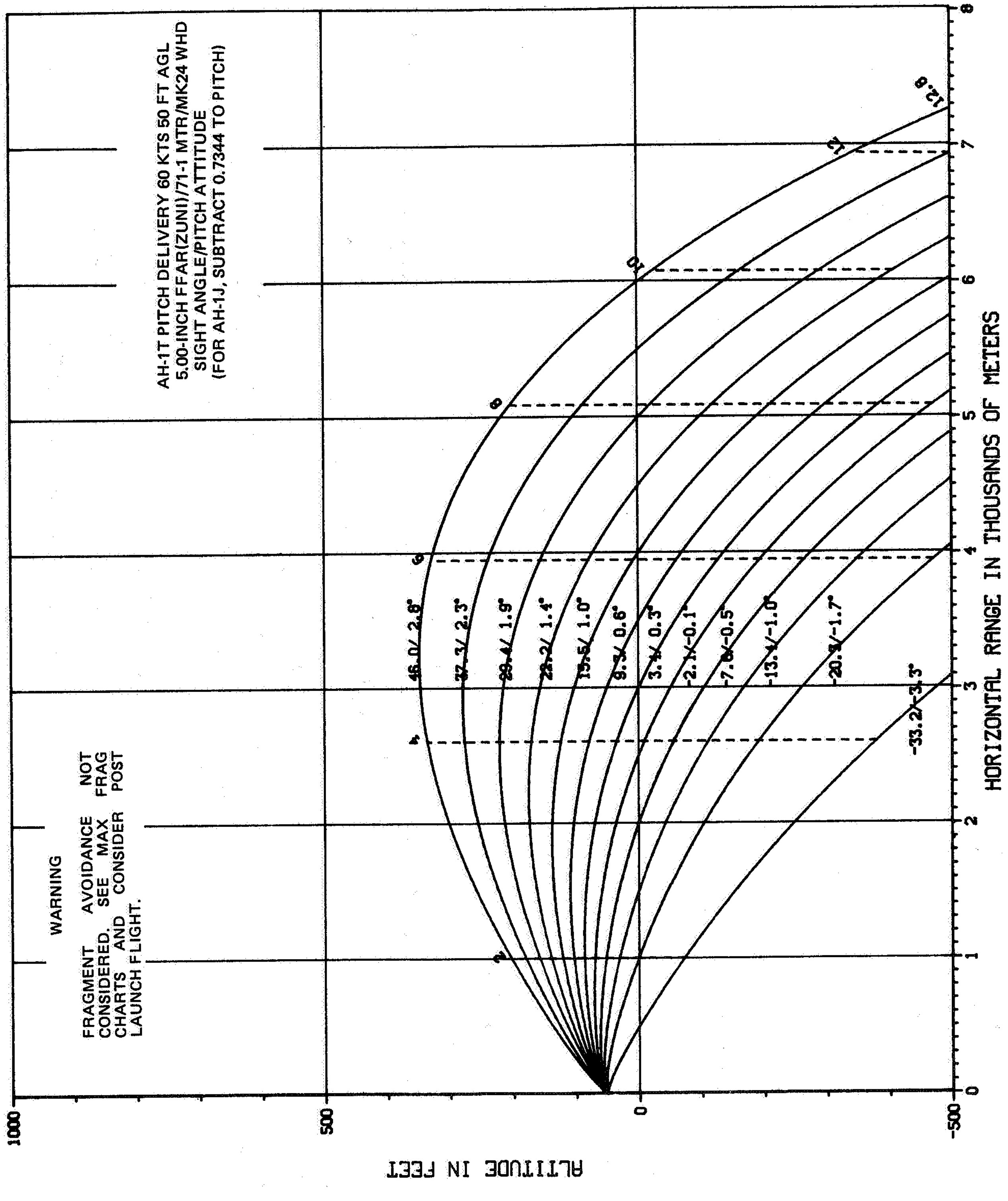


Figure H-3. 5-Inch FFAR Pitch Delivery (Sheet 3 of 6)

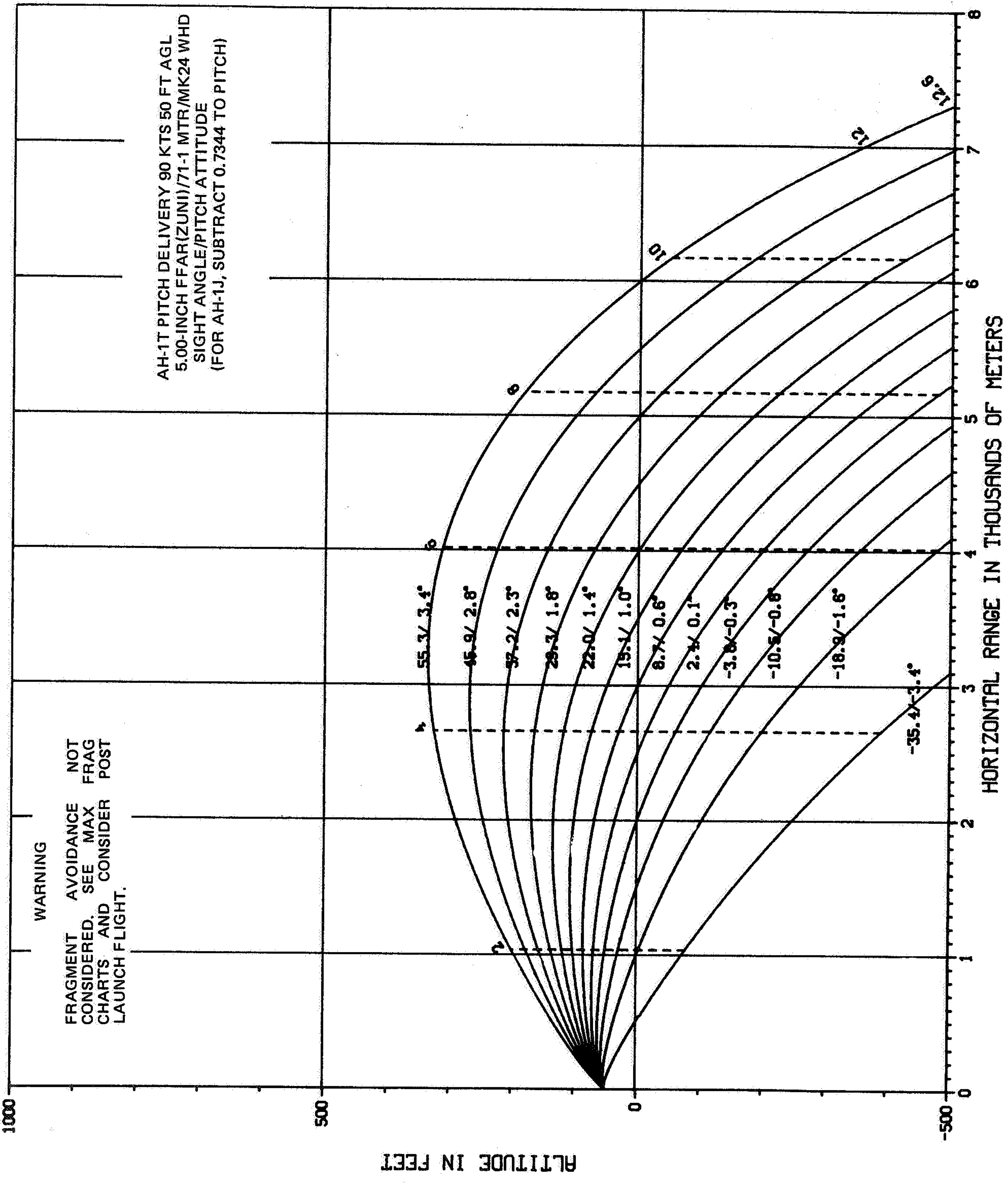
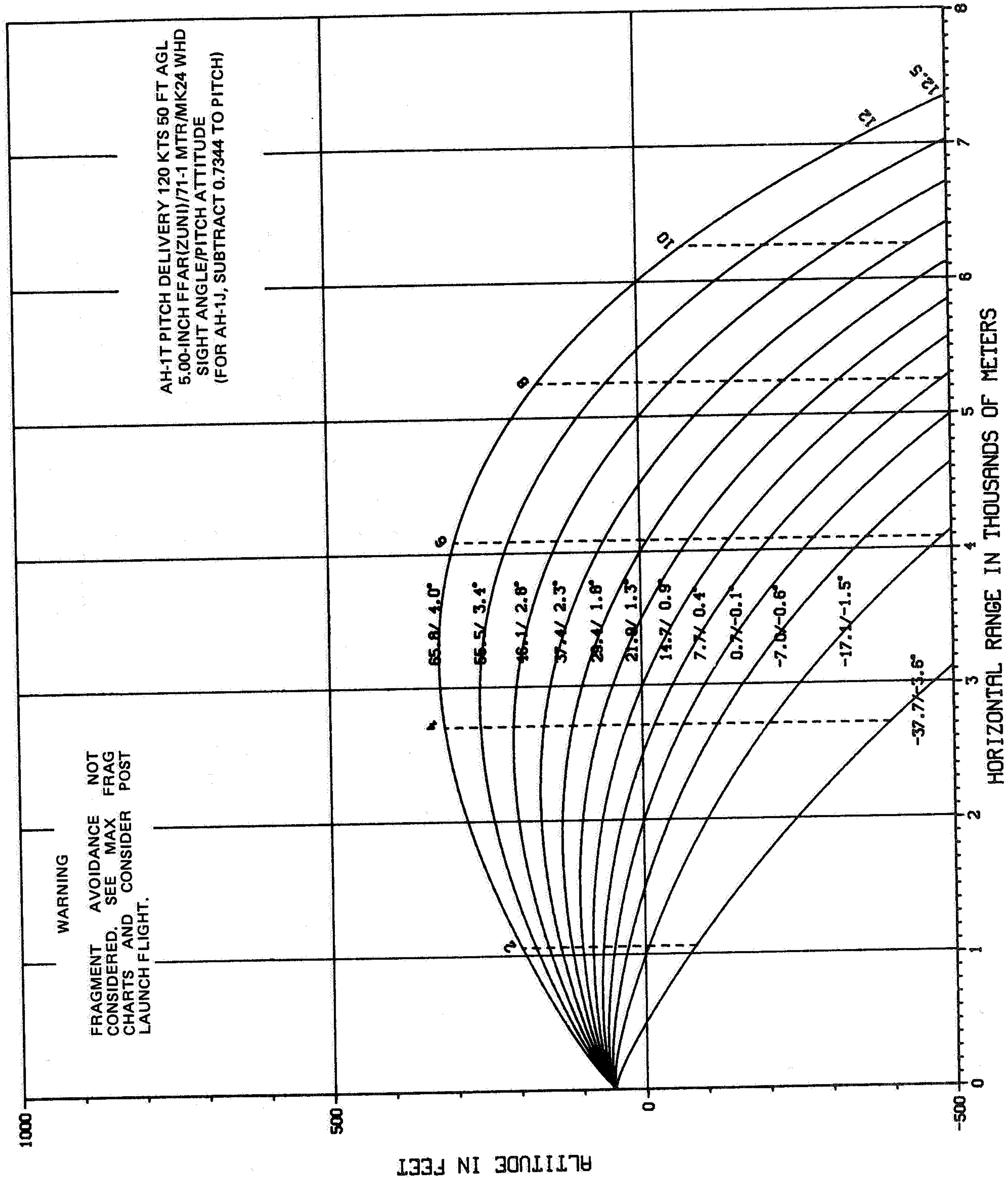


Figure H-3. 5-Inch FFAR Pitch Delivery (Sheet 4 of 6)

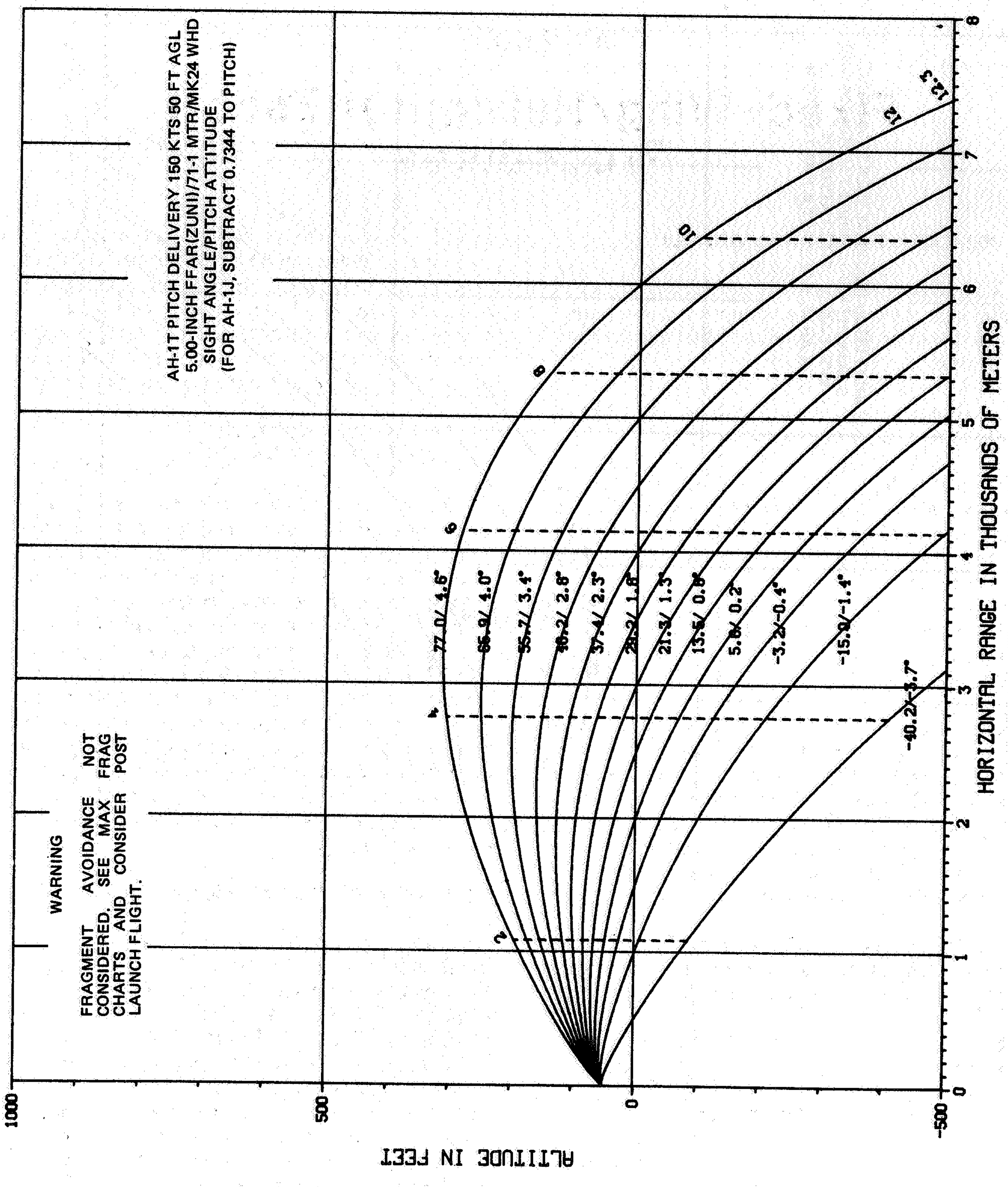


AH-1T PITCH DELIVERY 120 KTS 50 FT AGL
5.00-INCH FFAR(ZUNI)/71-1 MTR/MK24 WHD
SIGHT ANGLE/PITCH ATTITUDE
(FOR AH-1J, SUBTRACT 0.7344 TO PITCH)

WARNING

FRAGMENT AVOIDANCE NOT CONSIDERED. SEE MAX FRAG CHARTS AND CONSIDER POST LAUNCH FLIGHT.

Figure H-3. 5-Inch FFAR Pitch Delivery (Sheet 5 of 6)



AH-1T PITCH DELIVERY 150 KTS 50 FT AGL
5.00-INCH FFAR(ZUNI)/71-1 MTR/MK24 WHD
SIGHT ANGLE/PITCH ATTITUDE
(FOR AH-1J, SUBTRACT 0.7344 TO PITCH)

WARNING

FRAGMENT AVOIDANCE NOT CONSIDERED. SEE MAX FRAG CHARTS AND CONSIDER POST LAUNCH FLIGHT.

Figure H-3. 5-Inch FFAR Pitch Delivery (Sheet 6 of 6)

APPENDIX I

Fixed-Wing/Helicopter Escort Procedures

I.1 RESCAP/SEARCH AND RESCUE

The primary concern on a RESCAP mission is the safe and rapid extraction of the survivors. In order to accomplish this, the following considerations are in order:

1. Obtain visual/voice contact to assure status and authenticity of survivors.

2. Vary flight vigilance with respect to threat area. Do not lose maneuverability in an airborne threat area; there may not be room in the rescue vehicle for more passengers.

3. Be prepared to escort or direct the rescue aircraft into the pickup area and to escort during egress.

4. If weapons have been optimized for the mission, the survivors can be protected down to the mean lethal radius of the weapons to be used. If weapons have not been optimized for the mission, ensure that the flight knows precisely where the survivors are before any ordnance is expended. Preferred ordnance is the same as for close air support.

5. The rescue vehicle will be at its most vulnerable status at pickup time. This is when cover becomes most critical.

6. Act as on-scene commander until relieved by a designated rescue coordinator.

I.2 HELICOPTER ESCORT

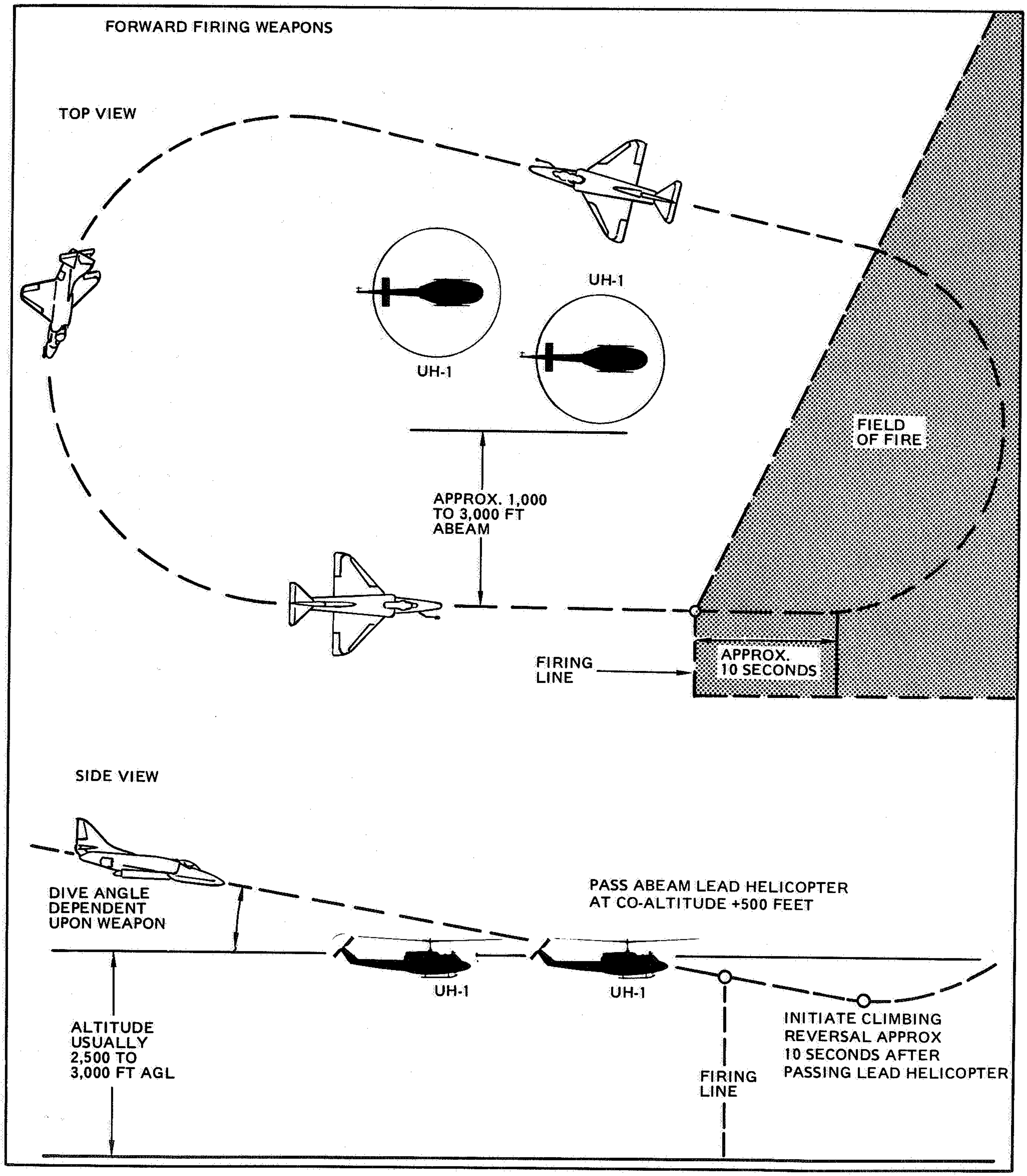
Escort retaliatory firepower creates a psychological deterrent to suppress enemy fire. Thorough escort briefing is mandatory and should include rendezvous, communication procedures, helicopter flight track and altitude, number of helicopters, and landing zone (LZ) locations. The track and maneuvering of the helicopters, the weather, and the terrain combine to dictate the escort pattern techniques required to reduce or suppress enemy fire.

I.3 EN ROUTE TACTICAL CONSIDERATIONS

Radio contact with the helicopter flight leader should be established prior to rendezvous. In-trail formation should be used to achieve spacing of the escort aircraft, while approaching the rendezvous. When visual contact between the two elements is confirmed, the helicopters will depart on track. The escort aircraft will then establish a racetrack pattern around the helicopter flight to provide a continuous series of potential firing passes. If the helicopter flight reports ground fire, the escort aircraft in the firing pass should respond with retaliatory fire. Retaliatory fire usually causes the enemy to cease fire. Typical escort patterns are shown in Figure I-1.

I.4 PREPLANNING CONSIDERATIONS

Prior to a complex helicopter operation, personal liaison must be established between the air control agencies: Tactical Air Direction Center (TADC), Tactical Air Controller (Airborne) (TAC(A)), Forward Air Controller (FAC or RAC(A)), and the helicopter and supporting attack aircraft units involved. The tactical situation will determine the technique of support. The degree of enemy opposition, weather conditions, number of helicopters employed, and the number of attack aircraft


FORWARD FIRING WEAPONS
TOP VIEW
UH-1
UH-1
FIELD OF FIRE
APPROX. 1,000 TO 3,000 FT ABEAM
FIRING LINE
APPROX. 10 SECONDS
SIDE VIEW
DIVE ANGLE DEPENDENT UPON WEAPON
PASS ABEAM LEAD HELICOPTER AT CO-ALTITUDE +500 FEET
UH-1
UH-1
ALTITUDE USUALLY 2,500 TO 3,000 FT AGL
FIRING LINE
INITIATE CLIMBING REVERSAL APPROX 10 SECONDS AFTER PASSING LEAD HELICOPTER

209900-763-1

Figure I-1. Helicopter Escort (Sheet 1 of 2)

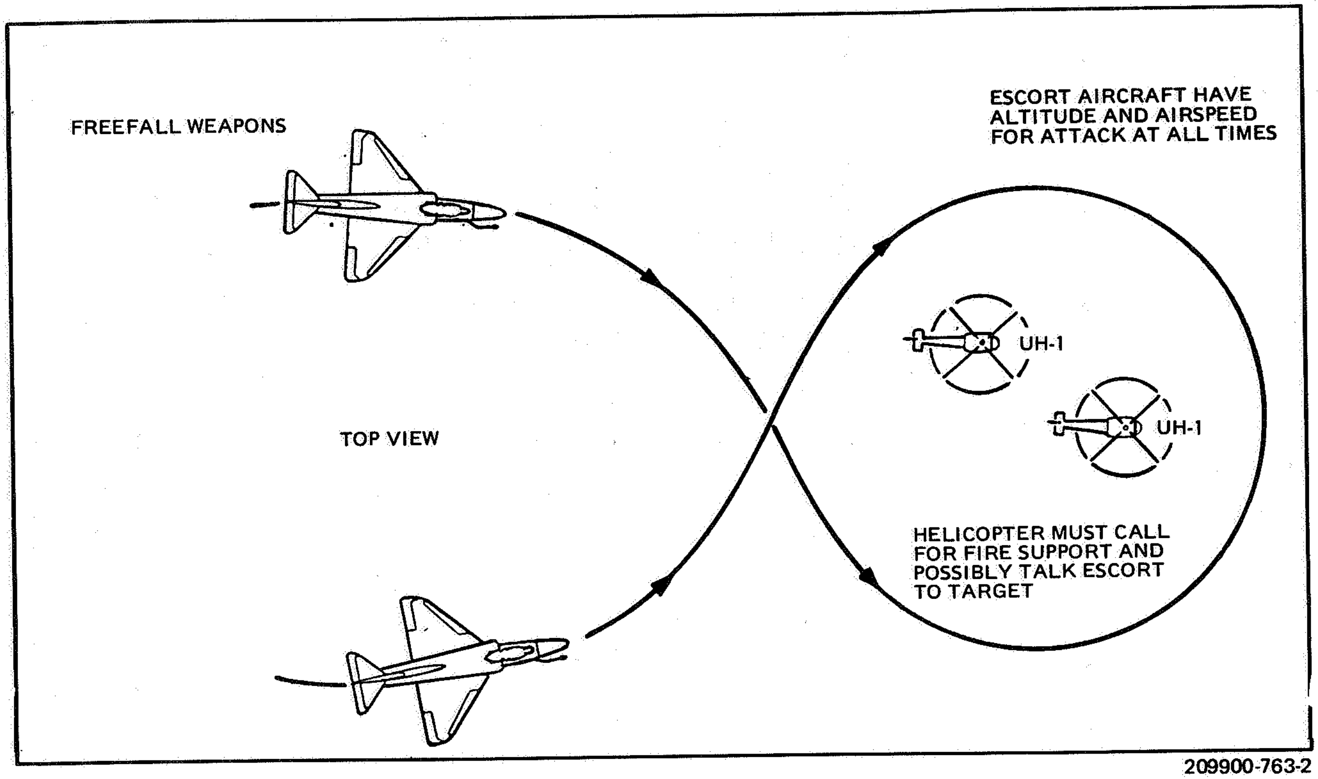

FREEFALL WEAPONS
ESCORT AIRCRAFT HAVE ALTITUDE AND AIRSPEED FOR ATTACK AT ALL TIMES
UH-1
UH-1
TOP VIEW
HELICOPTER MUST CALL FOR FIRE SUPPORT AND POSSIBLY TALK ESCORT TO TARGET
209900-763-2

Figure I-1. Helicopter Escort (Sheet 2 of 2)

assigned will cause variances in employment methods.

The division is the basic element for helicopter support missions. In some instances, in-flight refueling may be required to provide adequate time on station. In other instances, it will be necessary to plan for on-staton relief as soon as the fixed-wing aircraft have expended their ordnance. Preflight briefings should be as thorough as available information permits. Alternate plans of action should be briefed in the event of the tactical situation changing after the flight is airborne. (Alternate helicopter corridors, ordnance fuzing, and delivery variations are dependent on weather, alternate landing zones, and in-flight refueling procedures.)

Ordnance will depend on the type of helicopter support mission. The tactical situation may require mixed ordnance loads. Operation in close proximity to the helicopter imposes limitations on blast and fragmentation. For other operations, heavier ordnance may be used. When the mission is landing zone preparation, ground burst GP or HE bombs should be used judiciously because of the possibility of duds being seeded in the operating area of friendly troops.

I.5 WEATHER

Normally, an overcast of 1,000 feet and 3-miles visibility is considered minimum for attack aircraft operation in support of helicopters. The ordnance must be compatible with weather conditions to preclude fragmentation damage to aircraft. If the situation requires flying helicopter support in a limited airspace with adverse weather prevailing, only two aircraft should be in the immediate area of the helicopters. Extreme vigilance and precisin are of paramount importance when operating with numerous helicopters and attack aircraft under restricted visibility conditions.

I.6 AIR CONTROL/COMMUNICATION PROCEDURES

The TAC(A) is an experienced aviator who is airborne in the operating area for the purpose of coordinating aircraft movements and controlling air strikes.

The TAC(A) works with the various other control agencies, such as the Tactical Air Control Center (TACC), TADC, Direct Air Support Center (DASC), and the FAC or FAC(A). The TAC(A) usually can mark targets for attack aircraft. This is of particular value during the initial clearing of helicopter routes (corridors). The TAC(A) usually remains at an intermediate altitude and provides the helicopter and the attack flight leaders with direction and information concerning areas for avoidance or destruction.

The helicopter flight leader controls strikes by attack aircraft in the immediate vicinity of the helicopter formation. He determines whether to call for a strike or how to modify the helicopter flight route.

I.7 VISUAL SIGNALS

Pyrotechnics of various types and colors convey certain prearranged meanings such as identifying units as friendly, marking targets, and lifting or calling for support fire. The TAC(A), FAC(A), and each helicopter have the capability of visual signaling. It is important that each attack pilot be thoroughly prebriefed on the visual signals to be used.

I.8 SUPPORT OF HELICOPTER TROOP LIFT

When performing a troop lift, various combinations of transport helicopters proceed over a designated route (corridor) to a selected landing site. Attack helicopters generally provide escort. Normally, the helicopters will proceed along the corridors at an altitude above effective small arms fire (3,000 to 4,000 feet). The fixed-wing attack aircraft should CAP in a moving level pattern along the corridor at an altitude commensurate with conserving fuel and keeping the helicopters in sight. The escort pattern should keep one attack aircraft in position to deliver ordnance, when requested. A continuous *tilted dish* dive attack racetrack pattern may also be used as close to the helicopters as aircraft maneuverability and weapons effects permit. Low/slow, high-power, quarter-flaps tactics and delivery specifics apply. The close-in pattern calls for MRT roll-in from approximately 3,500-feet AGL. Attacks on either side ahead of and behind the helicopter formation are possible. Significant enemy activity may require four attack aircraft in the pattern. When enemy activity is minimal, the division can be split into sections (high and low), in either the tilted dish or a level racetrack pattern. The low-altitude, slow-speed pattern improves target acquisition, allows a tighter pattern, and requires less maneuvering airspace.

I.9 LANDING ZONE PREPARATION

Landing zone preparation is accomplished just prior to the arrival of the helicopter assault formation. The TAC(A) or FAC(A) will control the strike and indicate the direction of the attack, pullout direction, ordnance to be expended, and retirement instructions. The TAC(A) or FAC(A) as appropriate, will usually mark the target area with colored smoke.

Strikes will not be called on the landing zone (LZ) unless enemy obstacles to helicopter landing are apparent. Detonation of antipersonnel mines can be done with 20-mm gun fire. Attacks are directed at surrounding areas that provide the best cover for the enemy (hedge rows, tree lines, trenches, and so forth). The ordnance mix best suited for LZ preparation is a combination of 20 mm, napalm, rockets, and daisy cutter VT-fuzed bombs. A varying jinking, high-speed delivery pattern will afford the best protection from enemy ground fire.

CAP over the LZ after friendly troops have landed provides immediate response for close air support requests.

I.10 FIXED-WING AIRCRAFT AND ATTACK HELICOPTER COORDINATION

Coordinated efforts by attack aircraft and attack helicopters in a CAS mission are highly effective. The attack aircraft with heavy ordnance and napalm can attack and flush out entrenched troops. The attack helicopters can effectively bring direct fire on exposed enemy personnel. The FAC(A) is essential for coordination and control of air strikes in close proximity to friendly troops.

APPENDIX J

International Agreements

	NATO STANAG	ABCA SOLOG	CENTO STANAG	SEATO SEASTAG
Lane Minefields	2001	1R		
Marking of Contaminated or Dangerous Lane Areas	2002	124		
Patrol Reports by Army Forces	2003	6R		
Toxic Alarm System	2004	26		
Monitoring and Toxic Reports	2008	5R2		
Bridge Classification Markings	2010	24		
Operation Orders	2014	17R		
Route Classification	2015			
Operational Situation Reports	2020	16R		2020
Intelligence Reports	2022	2R2		2022
Method of Describing Ground Location, Areas, and Boundaries	2029			
Interrogation of Prisoners of War	2033	69		
Techniques of Land Minefield Laying and Recording	2036	18R		
Operational Road Movement Orders, Tables, and Graphs	2041	51		
Standard Procedures for Establishing Communications	2043	15R2		
Standard Procedures for Establishing Prisoners of War	2044	22R		
Emergency Alarm if Hazard Attack	2047	110	2047	2047

Rear Area Security and Rear Area Damage Control	2079	48R	2079	2079
Relief of Combat Troops	2082	49R	2082	2082
Battle Illumination	2088	108	2088	
Sign Posting of Radiologically Contaminated Areas	2094	111		
Reporting Engineer Data in the Field	2096	107		
Fire Coordination in the Land/Air Battle	2099		2099	2099
Principles and Procedures for Establishing Liaison	2101	104		
Reporting Nuclear Detonations	2102	123	2103	2103
Friendly Nuclear Strike Warning to Armed Forces Operating on Land	2104	130		
Radiological Survey	2112			2112
Recognition and Identification of Forces on the Battlefield	2129		2129	2129
Offensive Air Support Operations	2134			
Aircraft Marshalling	3117			
General Rules Covering the Transport of Loads by Helicopter	3468			
Standard Procedures Prior to Infantry/ Armored Fighting Vehicles Operations		222		
Helicopter Day and Night Tactical Formation Flying	3627			
Helicopter Tactical Refueling	3628			

APPENDIX K

Introduction to Radar Radiation Fundamentals

K.1 INTRODUCTION

Electronic countermeasures are actions taken to reduce the effectiveness of electromagnetic equipment and tactics employed by hostile air defense. In order to effectively apply countermeasures to the electronic threat elements, the survivability engineer should have a general understanding of the operation of electromagnetic equipment. In this appendix, typical radar systems and their operations are described. Radar is presently the most widely used electromagnetic detection and tracking system employed by the enemy. Many of the basic principles presented are applicable to other types of electromagnetic and acoustic detection systems as well. To simplify the presentation, examples of *ideal* cases are often used, and in actual practice the effects of system losses and inefficiencies result in an analysis procedure much more complicated than presented here.

K.2 GENERIC RADAR SYSTEMS AND TERMINOLOGY

A typical radio detection and ranging (radar) system consists of a transmitter, an antenna, and a receiver. The transmitter generates an electromagnetic signal, usually a tone frequency, that is either a continuous wave (CW) or short, repeated high-power pulses, each pulse containing many wavelengths. The signal is sent from the transmitter to the feed horn where it is focused on the antenna, much like an ordinary flashlight, where the antenna is the reflector and the light bulb is the feed horn. The feed horn signal is reflected from the antenna and is focused in space in either a fully focused *pencil* beam or a semifocused *fan* beam, depending on the shape of the antenna. If the signal strikes an electromagnetically reflecting object (i.e., aircraft, mountain, rain), the reflected signal will be scattered in all directions. Some of the reflected signal or echo will be in the direction of the radar receiver. The antenna used by the receiver to pick up the echo can be the same as that used to send out the signal, or it may be a separate antenna. (Radar systems in which the receiver is not at the same location as the transmitting antenna are referred to as bistatic radars.) The return signal is then processed to extract information on the reflecting object, such as its location in space. Echoes from non-aircraft are called *clutter*.

The time delay between the time a pulsed signal is transmitted until the time when it is received is a measure of the range or distance to the target. (Simple CW radar normally does not provide any range information.) The velocity of electromagnetic radiation is approximately 1,000 feet per microsecond. Thus, the time for a signal to travel to an object 1 nm (6,080 feet) away and return is 12 microseconds. The direction or azimuth of the target is provided by the direction in which the antenna is pointing. The height of the target can be determined by the elevation of the antenna for pencil beams. Two fan beams, one horizontal and one vertical, are required for height information.

In pulse radars, the same antenna is usually used to transmit and receive the pulsed signal. A short pulse is transmitted and the transmitter is turned off; this pulse is reflected by an object and returns to the antenna with the same characteristics as the original transmitted pulse.

As this procedure is repeated, the target's flightpath can be tracked. Modifications to this procedure and additional processing of the echo provide additional information, such as target velocity and the ability to detect a moving target from stationary clutter.

Air defense radars fall into two broad categories: surveillance radars and weapon or fire control radars. Surveillance radars are used to detect the presence of aircraft at long ranges and to provide the general view of the overall situation in the air needed to control the defense. They are also referred to as search, acquisition, early warning, or ground controlled intercept (GCI) radars. These radars normally operate at relatively low frequencies and use rotating antennas with wide beamwidth fan beams. Target tracking can be accomplished by surveillance radars as they continue searching (track-while-scan (TWS)). When the decision is made that the target is a threat and is within the field of a weapon control radar, the target information is passed to the assigned weapon control radar.

Weapon control radars normally operate over a small volume of space and handle relatively few targets. Their function is to provide the information necessary to allow the weapon to be brought to bear on the target and to destroy it. The output from the radar is used to determine the target's flighpath and predict its future position so the weapon can be pointed in the correct position to cause an intercept. Consequently, these radars must provide accurate measurement of the target location in angle and range. Accurate measurements can be obtained using higher signal frequencies and narrow beam widths.

There are three general techniques used by weapon control radars to track the target: single-target tracking, track-while-scan, and phased array. Single-target tracking is the classical form of tracking. Angular measurements are obtained either by conical scan or by monopulse. A conical scan uses a feed horn that moves in a circular path around the boresight of a pencil beam antenna. This causes the conical beam to scan a small volume of space around the boresight of the antenna. The echo from a target that is not located on the boresight will be modulated in amplitude as the horn rotates. Adjusting the antenna until there is no modulation of the echo centers the target on the boresight.

The monopulse system uses a single transmitted beam in conjunction with a cluster of several antenna or feed locations at the receiver. The direction to the target is determined by moving the antenna until the difference between the echoes received simultaneously at pairs of locations is minimized. Arrangements of four antennas or feeds can be used to determine both azimuth and elevation. This method is superior in accuracy to the conical scan and is expected to be found in many future systems.

Track-while-scan weapon control radars (TWS) scan a limited angular sector in a regular manner and develop target tracks with data obtained at the scan rate rather than continuously as in the case of the single-target tracking radar. The scan can be accomplished using a pencil beam or two orthogonal fan beams. The scanning can be accomplished mechanically (by moving the antennas) or electronically. The TWS radar can engage more than one target at a time.

In phased array radars, the antenna is not just a passive reflector, but instead consists of a number of elements called *phase shifters*. Each phase shifter can be individually controlled to delay its portion of the beam by different lengths of time. By adjusting the relative delay times of each phase shifter, the beam can be electronically directed to any desired angle from the antenna boresight up to 90°. Furthermore, the changing of the beam directions can be accomplished in microseconds. This type of radar can also produce pencil beams, fan beams, or almost any desired radiation pattern. It can track several targets with varying data rates. For example, targets at long range can be tracked with a low data rate, while tracking of maneuvering targets at close range can be accomplished with a high data rate. High-powered phased array radars can be built using separate signal amplifiers for each antenna element, thus avoiding one very large amplifier.

K.3 RADAR PARAMETERS

K.3.1 Decibels. The common unit of reference when discussing the signal strength of radar is the decibel. The decibel is a term related to the common logarithm of the ratio of two quantities. The following example will serve to demonstrate the use of this system of measurement. Suppose there are two radars whose output voltages are $V_1 = 5$ volts and $V_2 = 10$ volts. The ratio of their outputs is therefore:

$$\frac{10 \text{ volts}}{5 \text{ volts}} \text{ or } 2$$

By definition, this ratio is expressed in decibels as:

$20 \text{ Log}_{10}(V_2/V_1) = 20 \text{ Log}_{10}(10/5) = 20 \text{ Log}_{10}(2) = 6$ dB. This definition can be used for both voltage and current ratios, and with a little juggling, it can be converted to a rule for power ratios as well. Note that:

$20 \text{ Log}_{10}(V_2/V_1) = 2 \text{ X } 10 \text{ Log}_{10}(V_2/V_1) = 10 \text{ Log}_{10}(V_2V_1)^2$.

Since power is proportional to the square of the voltage, the above relationship can be expressed as:

Power ratio in dB = $10 \text{ Log}_{10}(P_2/P_1)$;

which in the example would be:

$P \text{ (dB)} = 10 \text{ Log}_{10} \ (10)^2/(5)^2) = 10 \text{ Log}_{10} \ (100/25) = 6$ dB.

For ratios less than one use:

$P\text{(dB)} = -10 \text{ Log}_{10}(P_1/P_2)$.

Some common increments in decibels should be memorized to allow easier comprehension of the magnitudes involved. Since the base of the common logarithm is ten, the following relationship exists.

Power Ratio		**Decibels**
.01	corresponds to	-20dB
.1	"	-10dB
1.	"	0 dB
10.	"	10 dB
100.	"	20 dB
etc.		

The second value to memorize is the three-decibel increment. Three dBs correspond to a factor of two; i.e., factor of:

2	corresponds to	3 dB
4	"	6 dB
8	"	9 dB

Why use these unfamiliar units? The answer is one of tradition and expediency. The advent of the scientific calculator is much more recent than the beginning of the development of radar. As logarithms were the basis of the slide rule, they were convenient to use since additions of decibels correspond to multiplication of the numbers. Likewise, subtraction of decibels is equivalent to division: Numbers, 2 X 10 X 4 = 80; decibels, 3 + 10 + 6 = 19 dB.

Another frequently referenced quantity is the half-power point, or the point where the output has been reduced to one-half of its maximum value. Since twice the power is equal to +3 dB, half the power would equate to -3 dB, 10 $\text{Log}_{10}(1/2) = -3$ dB. The point at which power is reduced to half its value is therefore commonly referred to as the -3 dB point.

The definition of the decibel is always a ratio. To express a number in terms of decibels, express it as a ratio with respect to one. However, in electronic countermeasures work, the standard reference point for power is not 1 watt, but instead 1 milliwatt is used as a compromise value between the large transmitted power levels and the extremely small power levels of the radar echo. When a power level is compared to a standard of 1 milliwatt (10^{-3} watts), it is written with the units dBm or decibels with respect to 1 milliwatt. For example, a power level of 100 hundred watts would be expressed as 50 dBm.

$$10\ \text{Log}_{10}(100/.001) = 10\ \text{Log}_{10}(10^5) = 50\ \text{dBm}$$

K.3.2 Signal Characteristics. An important aspect of understanding the operation of radar is the ability to compare, classify, and quantitatively discuss the differences and similarities in signals emitted from various radars. Each radar signal has a characteristic *fingerprint* that identifies and categorizes it as belonging to a special group of radar types. The first characteristic is the signal frequency f that is a measure of the number of harmonic oscillations in the signal in the specified time interval. The period of the signal T is the time interval for one cycle.

Because of the high frequencies associated with radar, two standard terms are commonly used to denote the carrier frequency. These are megahertz (abbreviated MHz and equivalent to 10^6 cycles/second) and gigahertz (abbreviated GHz and equivalent to 10^9 cycles/second). One hertz is equivalent to one cycle per second.

Radar signals are radiated as electromagnetic radiation and therefore propagate at the speed of light. The speed of light is denoted by the symbol c and approximately $c = 300$ meters/μ sec. It's a good number to commit to memory early in any work with electromagnetic wave theory.

Another important parameter used in defining signals is the wavelength of the signal λ. It is defined as either the distance the radiated signal travels during one period of the carrier frequency or the physical length of the wave (Figure K-1). The wave length can be computed from $\lambda = c\,T = c/f$ (or more commonly $c = f\lambda$).

Modern radars operate in a frequency range from 200 MHz to 35 GHz. The radar signals are commonly referred to as microwaves. To be totally accurate, the microwave region is defined as that region of the electromagnetic spectrum with wavelengths falling between the limits of 1 meter (300 MHz) and 1 millimeter (300 GHz). The specific frequency ranges or bands are described by either of two systems of reference (Figure K-2). Separate electronic warfare band designations have been assigned by the military to facilitate the operational control of electronic countermeasures techniques. For clarity, this text will always utilize the countermeasures band designators.

Most radar systems are capable of transmitting a signal that can vary in frequency over a frequency spectrum called the *operating band*, such as an I-band radar. Pulsed radars that can change their frequency from pulse to pulse within the operating band are known as *frequency agile radars*.

K.3.3 Pulsed and CW Radar. As discussed above, radars can be divided into one of two general categories: pulsed radars and continuous wave radars. Each type of radar has its own advantages and drawbacks. In order to compare

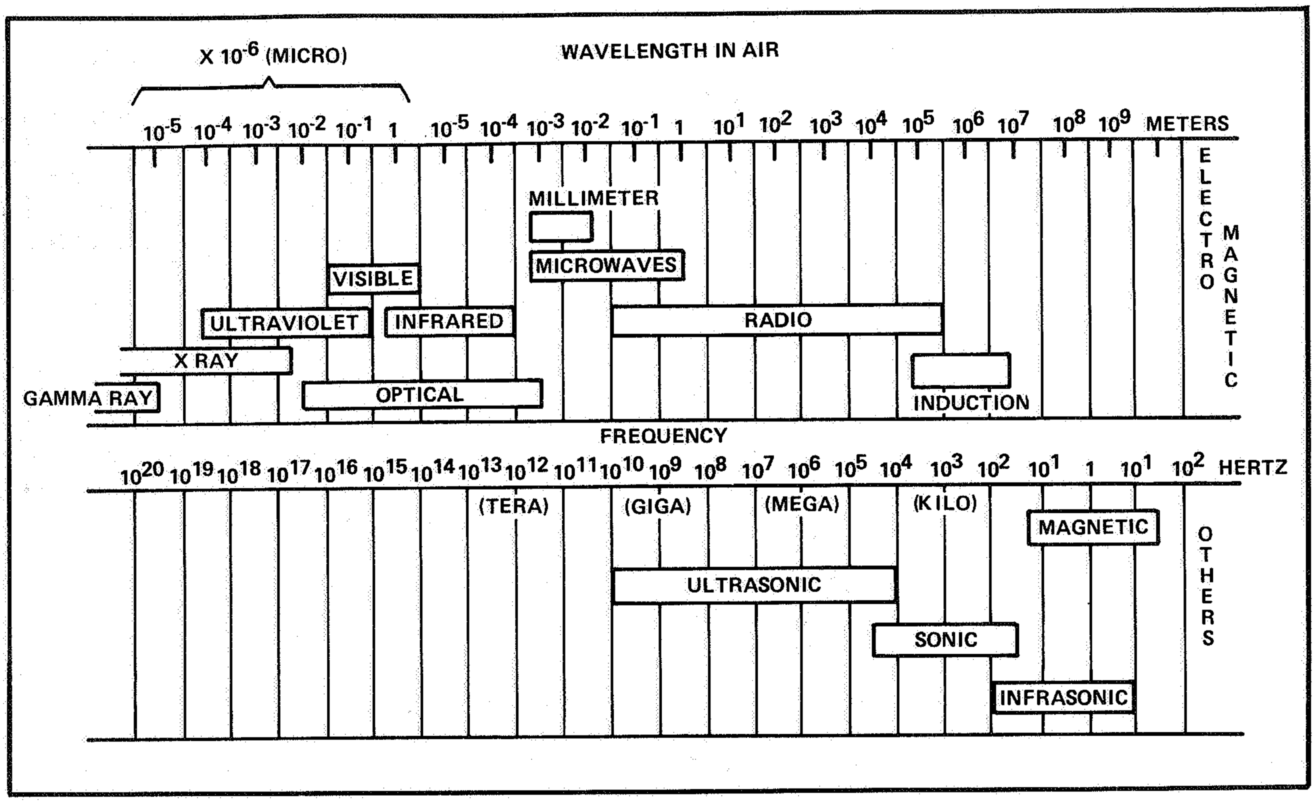

X 10-6 (MICRO)
WAVELENGTH IN AIR
10-5 10-4 10-3 10-2 10-1 1 10-5 10-4 10-3 10-2 10-1 1 101 102 103 104 105 106 107 108 109 METERS
MILLIMETER
MICROWAVES
VISIBLE
ULTRAVIOLET
INFRARED
RADIO
X RAY
GAMMA RAY
OPTICAL
INDUCTION
ELECTRO MAGNETIC
FREQUENCY
1020 1019 1018 1017 1016 1015 1014 1013 1012 1011 1010 109 108 107 106 105 104 103 102 101 1 101 102 HERTZ
(TERA)
(GIGA)
(MEGA)
(KILO)
MAGNETIC
ULTRASONIC
SONIC
INFRASONIC
OTHERS

Figure K-1. The Frequency Wavelength Spectrum

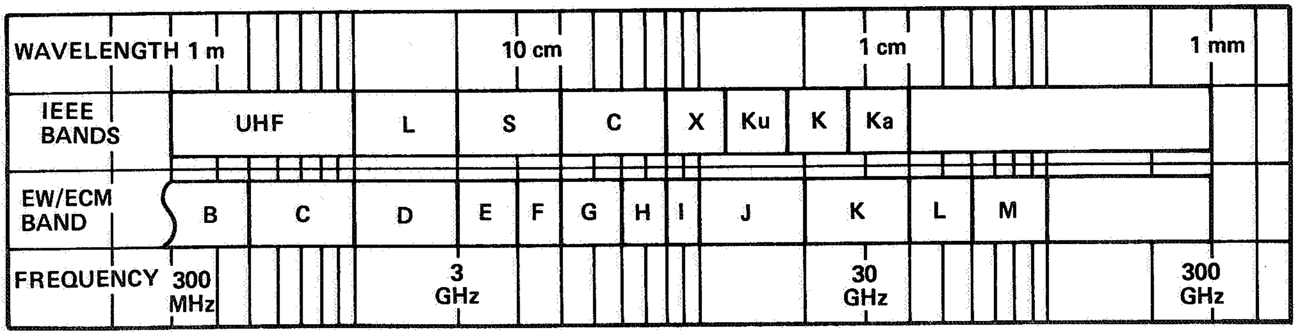


Figure K-2. Microwave Frequency Spectrum and Bands these two types, some additional signal parameters must be defined.

Two parameters that apply to pulsed radar signals are appropriately named the pulse repetition frequency f_r, sometimes abbreviated p.r.f., and the pulse width τ. The pulse repetition frequency limits the maximum unambiguous range of the radar. (An echo that returns from a distant target after a second pulse is transmitted could be interpreted as echo from the second pulse off a close target. Hence the term maximum unambiguous range.) Figure K-3 shows the time history of the output of a pulsed radar signal. Since the radar sends out a pulse of energy and then *listens* for the *echo* until a new pulse is sent out, the maximum time allowed for the signal to make a round trip transit from the radar to the target and back is determined by the interval between pulses. Mathematically this can be expressed as:

$$\text{Max. time for round trip} = \frac{1}{f_r} = \frac{2 \times R_{max}}{c}$$

$$= \frac{\text{Round trip distance}}{\text{Vel. of propagation}}$$

Hence, the maximum unambiguous range is given by:

$$R_{max} = c/2\, f_r.$$

Fire control radars which track targets at extremely close ranges can use very high pulse repetition frequencies compared to those of ear-

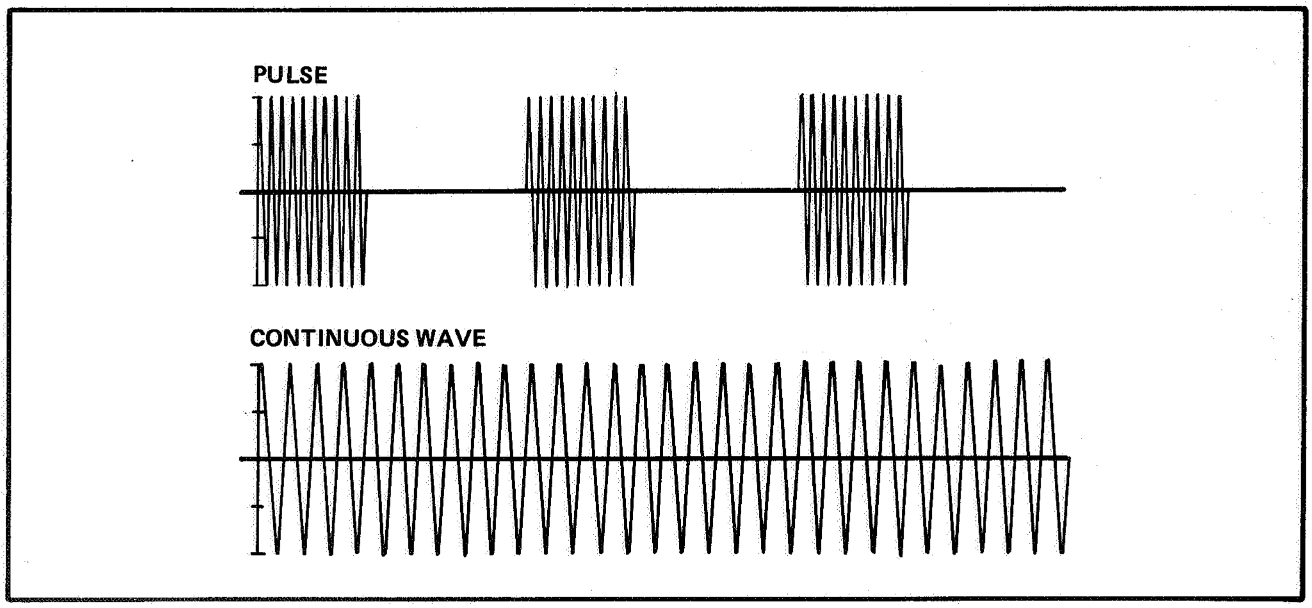


Figure K-3. Representative Pulse and Continuous Wave Radar Signals ly warning and GCL radars that operate at long ranges.

Pulse width is an important parameter for two reasons. First, it determines the amount of energy in a signal. If the output of a radar is set at a certain power level, the energy in the signal can be increased by leaving the power on for a longer period of time; i.e., varying the pulse width. For radars with very short pulse widths, a large power level is required to get sufficient energy into the signal in the short time that the transmitter is turned on. At the opposite end of the spectrum are the continuous wave radars that may operate at a much lower power level because they are transmitting all the time.

A second factor affected by pulse width is the resolution in range ΔR. As the pulse of energy transmitted into space is returned from the target, it is sampled by an electronic circuit called a *range gate* in the radar receiver. A range gate is a switch that opens at a time coinciding with a prescribed range and closes at a set time later. Because the receiver wants to *listen* to the entire pulse interval τ, its sampling cirucit must be divided by the range gates into *bins* that will sample for an equal length of time. These times are associated with the round trip range increments or resolution cells. The minimum resolution cell size which can intercept an entire pulse width is given by the expression:

$$\Delta R = c\tau/2.$$

This formula shows us that as the pulse width increases, the resolution in range degrades because the range bins are proportionately larger. The extreme case is again that of the continuous wave radar that has no range resolution because the pulse width is theoretically infinite. CW radars can be designed to give range information by the use of special modulation techniques, but in general are considered to give no range information from the signal itself.

Another signal parameter is the duty cycle, which is defined as the ratio of the time the radar is transmitting to the pulse repetition period T_r, expressed either as a decimal or as a percent or in decibel measure. The duty cycle for a continuous wave radar is 100 percent. Normal fire control radar duty cycles are on the order of .001.

The average power level of a radar is defined as the peak power level or the level during the transmitting cycle times the duty cycle.

$$P_{average} = P_{peak} \text{ X duty cycle}$$

K.3.4 Doppler. When a target is moving radially (i.e., toward or away from the antenna), the frequency of the echo is shifted from the original frequency by an amount dependent upon the radial velocity of the target. This change in frequency is called the Doppler frequency (f_d). Just like the sound waves from the whistle of a passing train, the Doppler frequency increases for the approaching targets and decreases for the ones that are receding. It is directly proportional to the relative radial velocity v_r of the target and the antenna and is given by the expression:

$$f_d = 2 \text{ X } f_o \text{ X } v_r/c$$

where f_o is the original frequency of the signal. Thus, the relative radial velocity of the target can be determined by:

$$v_r = f_d c/2f_o$$

when the Doppler frequency is known.

Continuous wave radars are generally theoretically able to determine the Doppler frequency most accurately and are therefore the types used when extremely accurate frequency shift measurements are required. In general, the ability of pulsed radars to be able to measure Doppler shift varies with the duty cycle, CW radars having the best discrimination since their duty cycle is 100 percent, and pulsed radars with very low duty cycles (i.e., short pulses and long interpulse periods) having the worst.

A very important application of the Doppler frequency is the detection and tracking of a moving target in the presence of strong echoes from stationary reflectors, such as ground clutter. Since the strong echoes from the stationary objects do not exhibit a Doppler frequency and the weak echo from the moving target does, special circuitry can use the Doppler frequency to filter out the stationary clutter and reveal the moving target. This feature is called a moving target indicator (MTI), and a pulsed radar with this capability is called a pulsed-Doppler radar or MTI radar.

A trade-off in accuracy between range resolution and velocity resolution is one of the compromises that must be made when developing a pulsed-Doppler radar. Figure K-4 illustrates the concepts involved in this trade-off procedure. In Figure K-4(a), a typical resolution cell for a pulsed radar is drawn in the range-Doppler plane. Notice that the short pulse width gives good range resolution, but very little Doppler discrimination. By going to the longer pulse, shown in Figure K-4(b), a resolution cell now gets better velocity discrimination but at the cost of resolution in range. This is typical of the pulsed-Doppler radar, where both range and velocity information on the target are desired. Figure K-4(c) is a resolution cell for a CW radar. Notice how the cell has been stretched (the total area enclosed by each cell boundary is the same) such that it now provides excellent velocity discrimination but accurate range information is no longer available.

K.4 SIGNAL AMPLIFICATION AND TRANSMISSION

Signal amplification at microwave frequencies is a major problem. Use of normal radio amplifiers is not possible because of the small wavelengths involved (e.g., E-band radar frequencies produce wavelengths that are 3,000 times shorter than those used in AM radio signals). The state of the art in microwave frequency amplifier and oscillator design is still advancing, but two common types of amplifiers still hold a major share of the market. These are the traveling wave tube (TWT) and the klystron amplifier. Figure K-5 shows diagrams of both of these devices. Each uses a beam of accelerated electrons that are velocity modulated within the device to arrive at the output in bundles. In the klystron, the electron bunches transfer energy to a resonant cavity at the output before striking a large collector. The dissipation of heat generated by this beam of electrons striking the collector is often a power limiting factor and one of the reasons that ECM equipment is often carried externally for good cooling.

In the traveling wave tube, the unamplified microwave signal is transmitted down a conductor wound helically around the beam axis. During the electron bunching process, certain electrons are decelerated, and the kinetic energy lost in this deceleration process is transformed into energy in the electromagnetic signal on the conductor. The strength of the signal increases continually along the tube until an optimum point is reached, after which further extension to the process no longer increases the power and may reduce it. The TWT is much lighter in weight than the klystron but is restricted to much lower power levels. Klystrons are normally used in transmission amplifiers and TWs in receiver amplifier or transponder applications.

Another device worth mentioning is the magnetron oscillator. This is often the power oscillator that generates the high-power signal

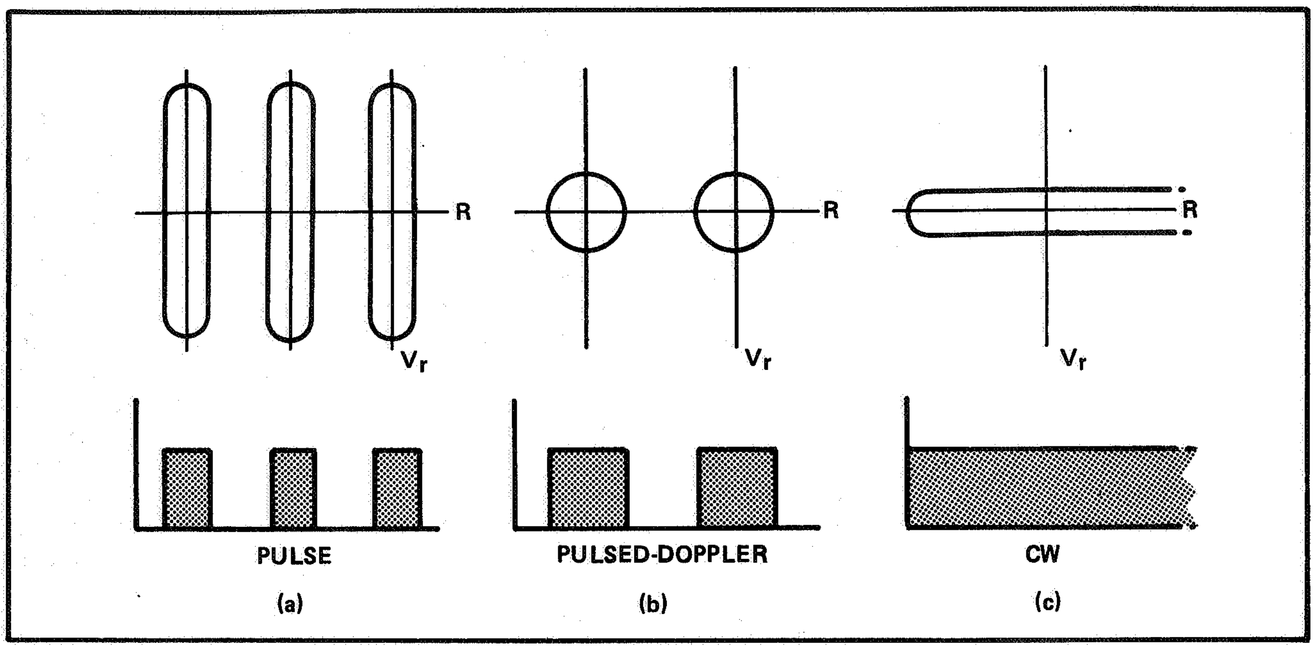


Figure K-4. The Changes in Radar Resolution Cell Orientation With Variations in Duty Cycle

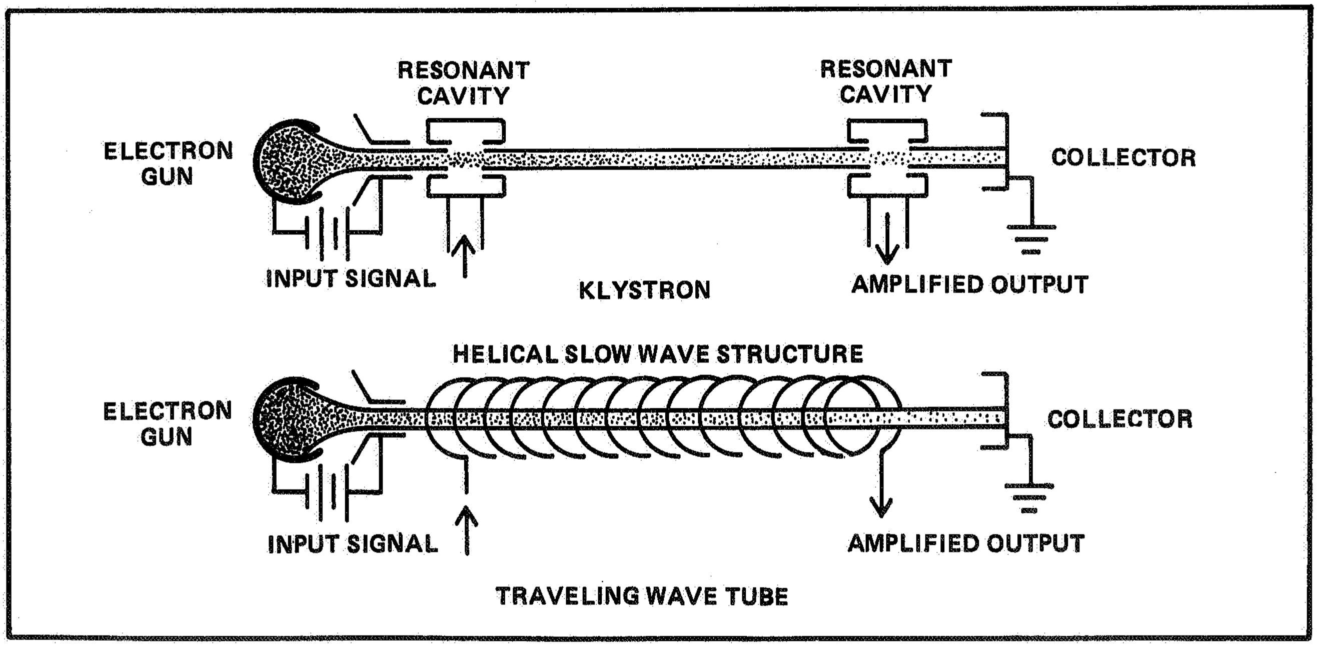


Figure K-5. Microwave Frequency Amplifiers that is gated off and on to create the radar pulse. The output of the magnetron may also be transmitted continuously, as in CW radars. In microwave engineering, as well as in other fields, there has been an incentive to shift from older technologies to those using semiconductor technology. There are presently a growing number of semiconductor devices that are capable of performing effectively in the microwave region. However, the present limitation is one of maximum power, and that is where the klystron, the TWT, and the magnetron continue to find application.

Another problem is how to get the microwave energy from the amplifier or oscillator to the antenna. Again, because of the small wavelengths involved, the microwave energy may not propagate at all along conventional wiring, and when it does it will only be with extremely high losses. Wave guides must be used for signal propagation in the E-band and above. This is accomplished by setting up repetitive resonant electromagnetic fields within the guides as shown in Figure K-6. Standard wave guides are both round and rectangular in cross section and decrease in size proportional to the signal wave length. Because of the repetitive nature of the fields enclosed within the guides, they must be carefully matched in length as well as in cross section so that the resonant field will terminate in the proper phase for maximum power transfer.

The wave guides connecting components within a radar system are often referred to as *plumbing* because of their resemblance to pipes in a water system.

K.5 ANTENNA PARAMETERS

The antenna on a radar serves two primary purposes. First, it directs and shapes the radar signal, and second, it provides a gain to both the signal and the echo.

A standard unit of a solid angle is called *steradian.* As the radian in a two-dimensional circle is defined as the angle subtended by one radius length measured along the circumference, a steradian is the solid or continuous angle at the center of the sphere that encloses a surface measured on the surface of the sphere, the area of which equals the radius of the sphere, squared. The entire solid angle on a sphere is equal therefore to 4π steradians (the area of a sphere is given by $A = 4\pi R^2$ or 4π areas of size R^2).

K.5.1 GAIN. Antenna gain is a measure of the power in the beam radiated by the antenna relative to the power that would have been radiated had the antenna been omnidirectional. Gain G is related to antenna size and frequency by the following formula:

$$G = 4\pi\rho \ A/(\lambda)^2 = 4 \ \pi \ A_e/(\lambda)^2$$

where A is the physical aperture or the total frontal area of the antenna and ρ is the antenna efficiency factor. A nominal value for ρ is 0.6. These two quantities are sometimes multiplied together and called A_e, the effective aperture.

Two features that should be noted are that gain is proportional to area (i.e., dimension squared) and inversely proportional to wave length squared (i.e., directly proportional to frequency squared). Thus, to get appreciable gain, one of two choices must be made: either (1) a very large antenna, or (2) a relatively high frequency. Radars that fit in the nose of an aircraft must be limited in size; therefore, sufficient gain can only be obtained by going to a high frequency. This is one reason that most airborne radars operate in the I- and J-bands at frequencies much higher than those generally used for ground-based radars.

K.5.2 Beamwidth. The beamwidth of the transmitted signal is defined as the width of the

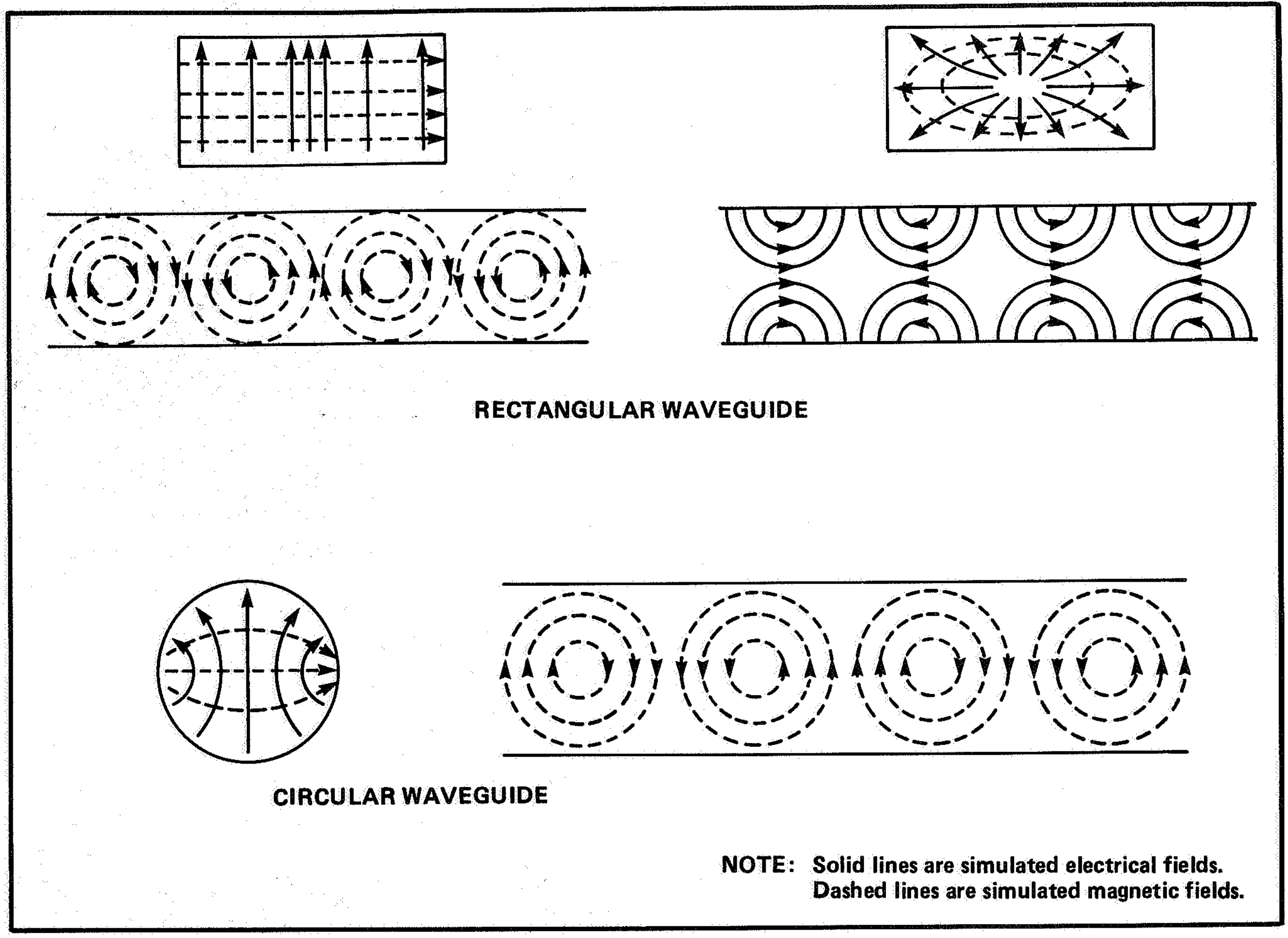

RECTANGULAR WAVEGUIDE
CIRCULAR WAVEGUIDE
NOTE: Solid lines are simulated electrical fields.
Dashed lines are simulated magnetic fields.

Figure K-6. Resonant Field Distributions

beam at the half-power points. In general, beamwidth is inversely proportional to the aperture width of the antenna. By working with the gain formula, the following rule of thumb for the beamwidth of a parabolic dish antenna is:

$$\text{BEAMWIDTH (in degrees)} = 70\lambda/L$$

where L is the maximum diameter of the dish.

Different antenna shapes are used to attain beam patterns optimized to a specific mission. Surveillance radar antennas are wider than they are tall so the radiated pattern is a vertical fan giving good azimuth resolution while covering a large sector in elevation. Figure K-7 shows a typical search radar antenna pattern.

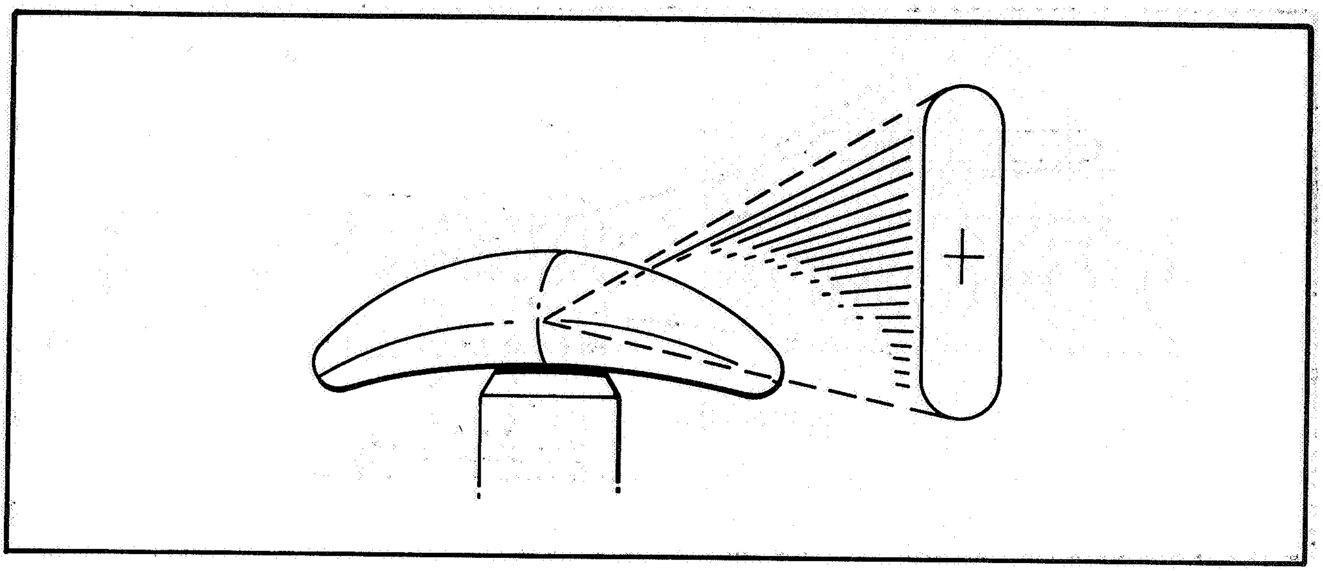


Figure K-7. Antenna Pattern for a Search Radar

The FANSONG track-while-scan radar used with the SA-2 Guideline missile uses two separate antennas to create a two-axis resolution by superimposing the sweep of two (elevation and azimuth) fan beams. Figure K-8 shows the antenna pattern of the FANSONG radar.

Tracking radars that use a symmetrical dish-shaped antenna have the narrow, high-resolution beam pattern referred to as a pencil beam. These pencil beams are so narrow they cannot be used to scan for a target, but once *locked on*, they provide extremely accurate directional information to the radar. Figure K-9 shows the antenna pattern of a typical pencil beam type of radar using the conical scan technique for tracking. Occasionally, a symmetrical antenna will be used as an illuminator rather than a tracker. In those instances, normally associated with a semiactive missile guidance system, the radar does not have to supply accurate guidance information to the missile or artillery weapon, but it does need to maintain a constant target echo for the missile to home in on. In these instances, a wider symmetrical beam is used.

Another important type of antenna is the electronically scanned radar (ESR) that uses the phased array antenna. These antennas consist of a multitude of transmitters rigidly mounted in a regular preset pattern. By computer controlling the phase shift of the signals to each of these elements, the radar beam can be electronically scanned back and forth at speeds no longer limited by the mechanical inertia of the antenna. Because the antenna no longer needs to move in scanning, such an antenna mounted in the nose section of an aircraft can be larger with an inherent increase in gain. In addition, and probably more important, the beam direction can be changed so rapidly that by multiplexing the signals, the radar can track several targets, search for other targets, and guide missiles simultaneously. In the case of navigational radars, signals from the inertial platform can be used to maintain the antenna beam in a desired angle with the horizon. Because the antenna is fixed, there is no need to worry about the effects of high normal

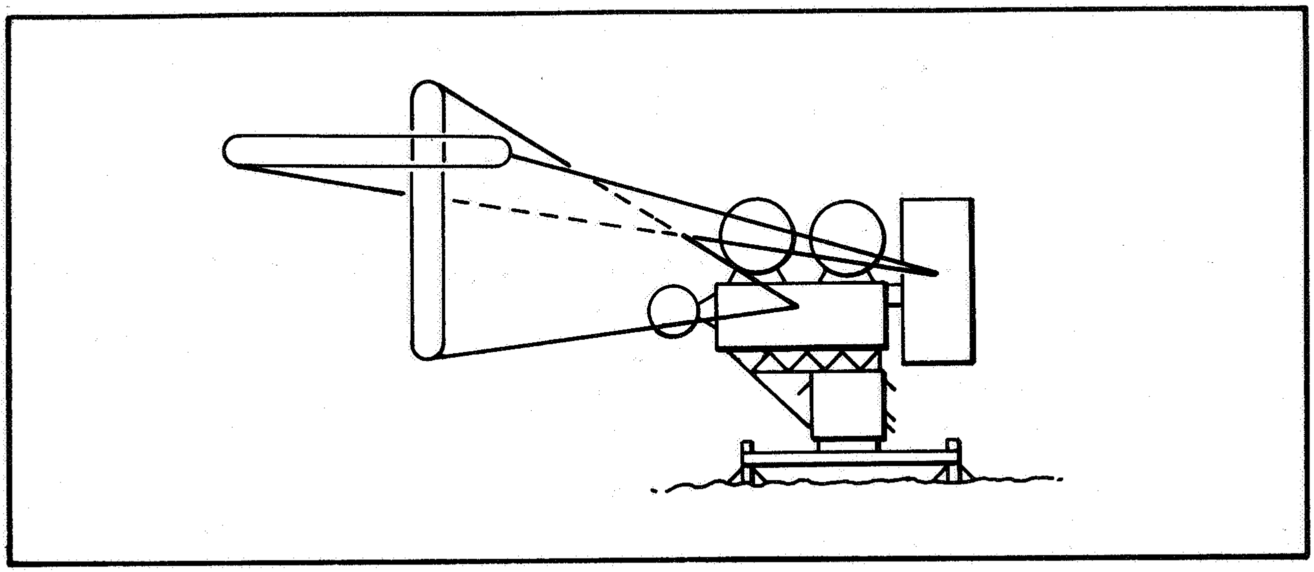


Figure K-8. Antenna Pattern for the FANSONG TWS Radar Trough Antenna

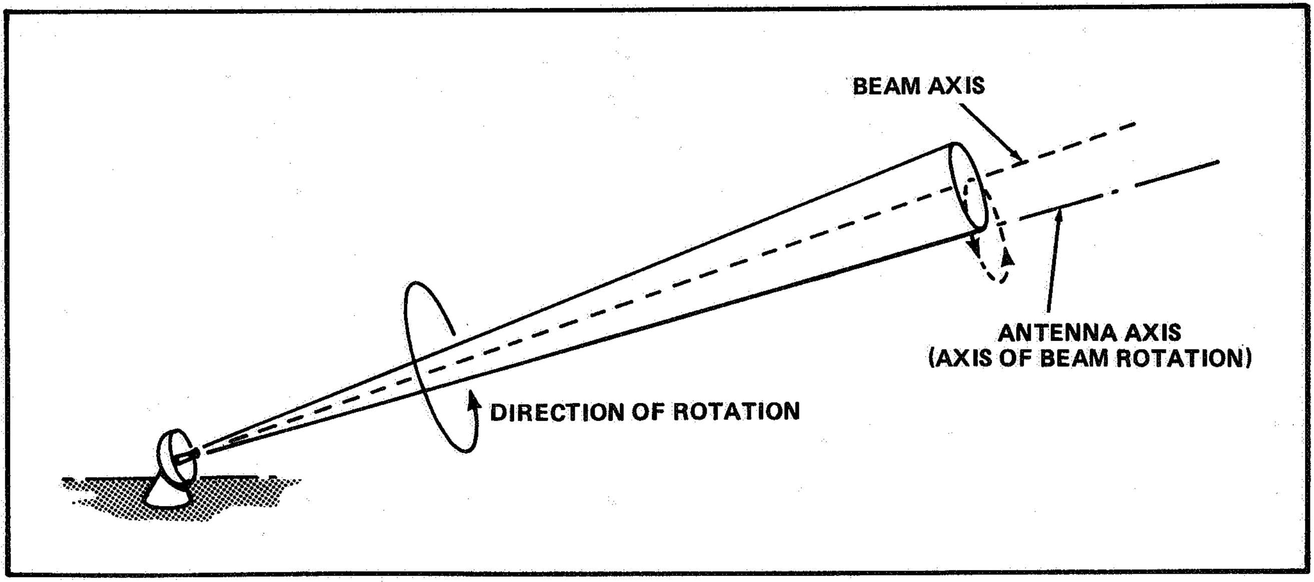


Figure K-9. Antenna Pattern for a Conical Scan Tracking Radar loadings encountered during air combat maneuvering and bombing run pull-outs. In addition, the mechanical caging mechanism required for catapult takeoffs and arrested landings aboard the carrier can be eliminated. Figure K-10 shows how the phase shifters in one row of a phased array delay the signal to direct the beam. Finally, since the phased array number of elements is quite large, the power capacity of each individual transmitter is reduced, paving the way for the use of semiconductor devices.

K.5.3 Polarization. Electromagnetic waves radiated by any antenna are always *polarized*; i.e., the electric field and the magnetic field in the wave are perpendicular to each other. If the electric field is perpendicular to the Earth, the wave is vertically polarized; if horizontal, then it is horizontally polarized. It can also be at some intermediate angle between these two. The antenna determines the angle of polarization. Plane polarized antennas that send out horizontally polarized signals will also receive only horizontally polarized signals. To account for the situation when the polarization of the receiving antenna is unknown, the signal can be sent out as a circular polarized wave. In this case, the polarization of the wave rotates at the signal frequency.

K.5.4 Sidelobes. There is another particular feature of the signal beam created by the antenna that offers an excellent opportunity for a countermeasure. That feature is called *sidelobes*. Sidelobes in the beam are created when the edges of the antenna are strongly illuminated by the signal from the feed horn. Lowering the intensity at the edges by tapering the feed horn signal reduces the sidelobe, but also reduces the gain of the antenna.

K.6 THE RADAR EQUATION

Now that the fundamentals of radar systems have been presented, the following is the basic relationship that determines the effectiveness of ECM. With a hostile radar average power output P_r, determine the level of power in the echo S returned to the receiver. Figure K-11 shows some of the variables that affect this relationship.

If the power of the radar is radiated uniformly in all directions, it will be distributed evenly over the surface area of a sphere located concentrically with the source of the power. At any range r, this area is given by the expression $4 \pi r^2$. Divide the power by the area to get the power density at the target range R. The radar antenna has a gain factor G_r. Thus, power density at the target is given by $(P_r \times G_r)(1/4 \pi R^2)$ = Power density at target where the first term expresses the power transmitted in the beam, and the second term relates the decrease in density with range. Multiplying the power density by the reflective area or radar cross section of the target, the power reflected at the target is as if the target were the source of power. To get the power density of the echo at any distance from the target, divide the power density reflected at the target area of the reflected sphere with its center at the aircraft. The power density of the echo is that at the radar receiver, so the radius of the sphere is again given by R, and the area of the echo is given by $1/4 \pi R^2$. The antenna creates a gain in the echo of A_e, just as it does in the transmitted signal. Thus,

$$S = (P_rG_r)(1/4\pi R^2)(\sigma)(1/4\pi R^2)(A_e)$$

(P_rG_r) = POWER in the beam

$(1/4\pi R^2)$ = power DENSITY at the target

(σ) = POWER at the target

$(1/4\pi R^2)$ = power DENSITY of the return at the radar

(A_e) = POWER received at the radar

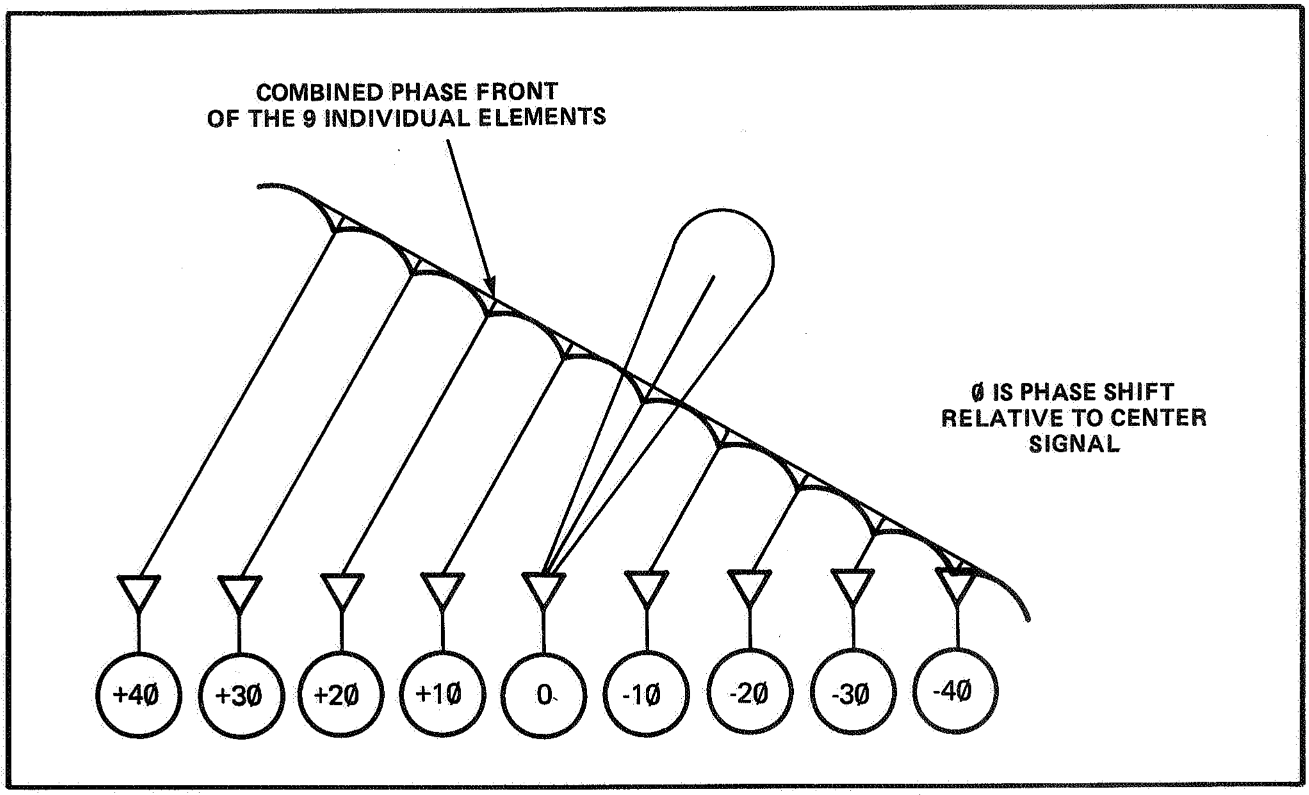


Figure K-10. Beam Deflection in a Row of Phased Array Antenna Elements

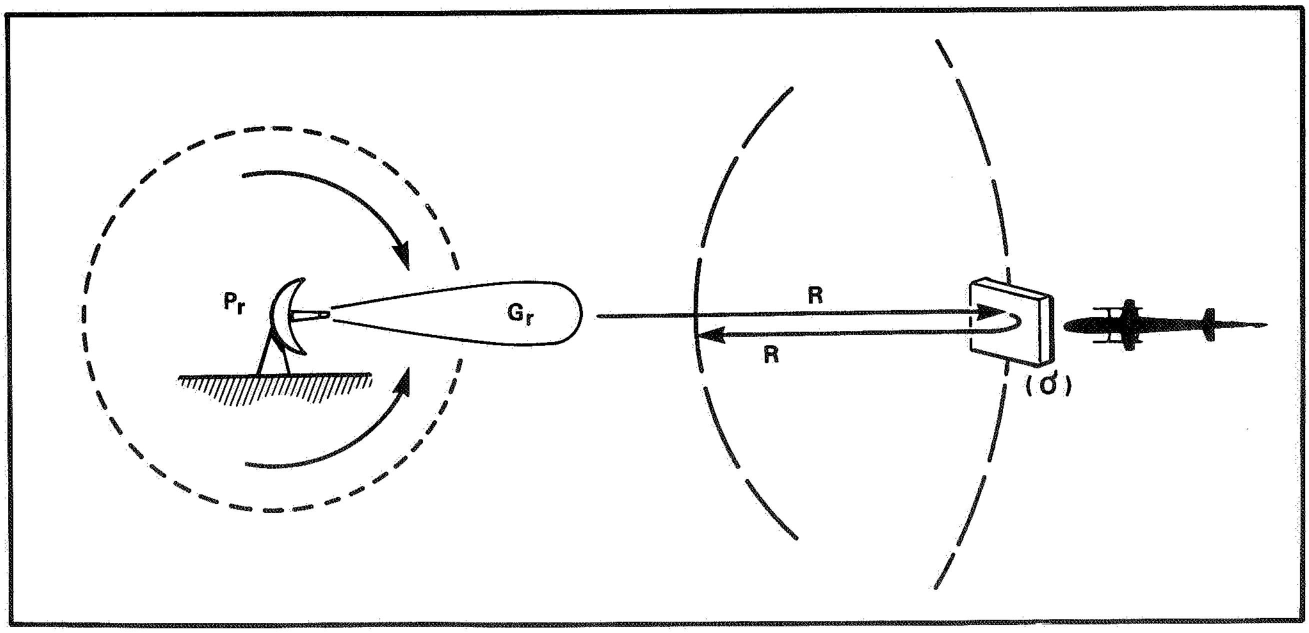


Figure K-11. Basic Geometry of the Radar Problem

The above equation shows the various factors that combine to make up the *radar equation.* This equation can be written in several different ways. By combining terms and using the relationship between gain and effective area of the antenna, the following forms of the radar equation can be derived:

$$S = \frac{P_r G_r A_e \sigma}{(4\pi^2)\ R^4}$$

$$S = \frac{P_r G_r^2 \lambda^2 \sigma}{(4\pi^3)\ R^4}$$

$$S = \frac{P_r A_e^2 \sigma}{4\pi(\lambda)^2\ R^4}$$

If the signal return is equal to a value that is the smallest echo detected in the radar, S_{min}, the radar equation can then be solved for the maximum range of the radar R_{max}; i.e., that range where the radar echo has just reached its minimum value and beyond which it would be undetectable.

$$R_{max} = 4\ \frac{P_r G_r A_e \sigma}{(4\pi)^2\ S_{min}}$$

It is important to note here the fourth root relationship. For instance, doubling the output power of the radar would only increase the range 19 percent. Reducing the radar cross section by a factor of 10 will only cause a 40-percent decrease in maximum detection range. However, this does not mean that signature reduction is not advantageous.

One additional feature that should be presented before proceeding further is the losses that result during atmospheric transmission of radar signal. In calculations of the maximum range of the radar, the ideal maximum range is calculated and then that result is used to find the actual maximum range through an iterative process. The details of this calculation are well beyond the scope of this text; however, what is important to note is the fact that atmospheric attenuation increases with increasing frequency. This is shown in Figure K-12. Note the increase in the loss at a fixed range as the frequency varies.

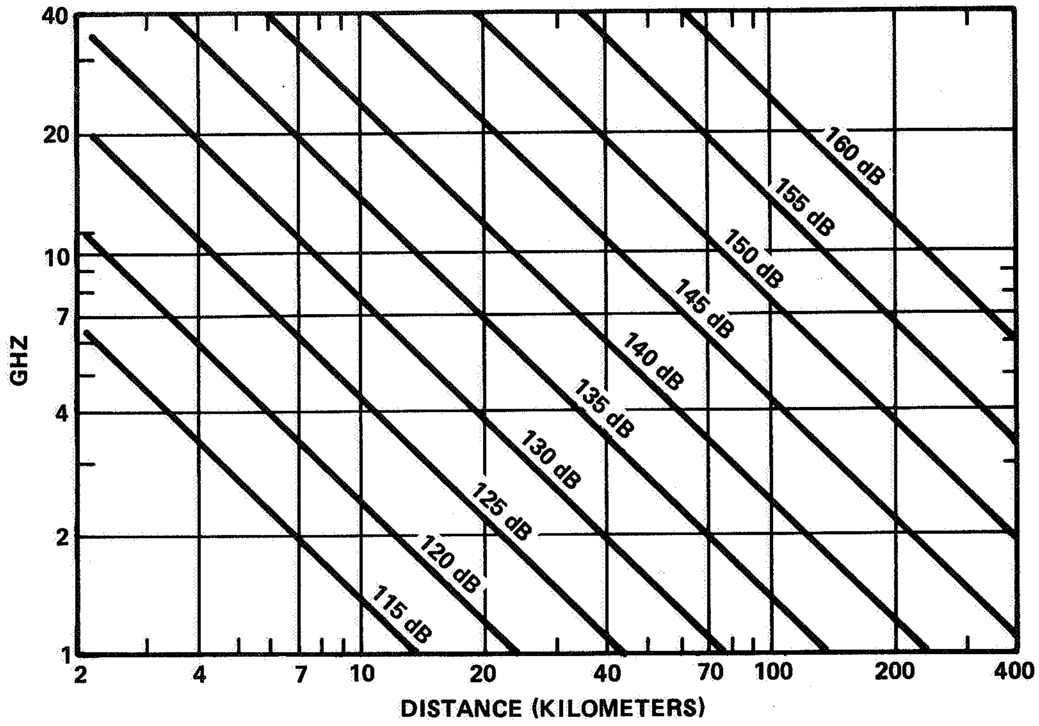


Figure K-12. Free Space Path Loss as a Function of Frequency and Range

APPENDIX L

Forward Arming and Refueling Point (FARP) Operations

L.1 GENERAL

1. MISSION. The FARP provides fuel and arming/dearming necessary for the training and operations of helicopters. The FARP should allow a minimum number of four aircraft to simultaneously refuel. FARPs are normally temporary facilities, transitory in nature, and established for a specific duration and mission. This appendix is intended as a general guideline for conducting safe FARP operations in an unprepared area. The scope of flight operations in the FARP area should include, but not be limited to, individual aircraft, sections, or divisions of aircraft requiring rearming and refueling.

Procedures cover both day and night operations at and in the general vicinity of the FARP. All current safety regulations and instructions should be strictly adhered to.

2. LOCATION. Ideally, the FARP will be located approximately 30 kilometers from the forward edge of the battle area (FEBA) or line of contact. This positioning ensures it is back far enough to prevent enemy preparatory fires from targeting the FARP, yet allows the quick turnaround of both helicopters and logistical transportation supporting the operation. The tactical dispersion of the FARP is terrain dependent. It must allow for ground vehicles, aircraft operations, material movement, and should provide terrain masking for cover and concealment.

Air units should select locations where equipment and helicopters can be hidden by natural camouflage from aerial reconnaissance detection. The use of treelines and wooded areas where vegetation is thick, good drainage, and adequate room for tactical dispersion, should be of primary importance. In areas where vegetation is unfavorable, consideration should orient on the use of shadows, natural folds of the terrain (desert), rocky areas, or anything that will break up the outline of FARP operations.

A good place to hide helicopters and FARP equipment is in or near towns and villages. Helicopters can either be placed in structures or hidden in the shadows. Also, towns and villages provide intersecting road networks, hard land for easy ground movement of aircraft, wheeled-vehicle movement, and an excellent night operation capability.

After selection of the site, preloaded supplies (forward area refueling equipment, bladders, ammunition, etc.) can then be transported to the site by trucks along with the material handling equipment and the FARP personnel. CH-53 and/or CH-46 helicopters may be used to initially emplace the FARP. Resupply may be accomplished by air or surface transportation.

L.1.1 Considerations for Establishing FARPS. In tactical operations (offense, defense, and retrograde), the FARP should be positioned based on these considerations:

1. Distance to, and the stability of, the forward edge of the battle area (FEBA)

2. Required time-on-station

3. Security requirements for the FARP

4. Enemy ability to destroy the FARP with indirect fire

5. Availability of adequate road networks

6. Distance between the FARP and the nearest class III and V supply points

7. Command and control requirements

8. Proximity to the main supply route (MSR)

9. Coordination with the logistical effort.

An alternate means of establishment could be by CH-53 or CH-46 helicopters. Tactical operations requiring rapid FARP emplacement, initial stocking and resupply, or displacement which cannot be accomplished by ground transportation due to time, distance, inadequate road networks, terrain, and/or enemy-controlled area, dictate establishment and support by air. Due to the required quantities of fuel and ammunition and other priorities placed on cargo helicopters, aerial resupply of the FARP should be limited. In addition, continuous aerial resupply of the FARP increases the probability of detection by enemy electronic warfare (EW) and visual measures.

Under certain situations, a combination of aerial and ground established FARPs may be operationally desirable. For example, if an attack helicopter squadron received a very rapid commitment order, the FARP may be initially established by air with enough class III and V supplies for one turnaround per helicopter. Continued operation will rely on surface transportation.

FARPs are usually established in or near forward assembly areas. Locations and routes to and from FARPs should be masked from radar detection.

Enemy radar should be assumed to be on any high ground or prominent terrain occupied by enemy forces. A line of sight analysis should be made to determine the FARP mask. Then, three or four points with routes leading to the FARP which are masked from radar detection should be established and used by aircraft going to the FARP. As teams return from missions to the FARP, they should fly to one of these known masked points and then fly masked from radar detection to the FARP. Upon leaving the FARP, the helicopters should return to a masked point and then, if required, move with high speed to resume their assigned missions. By using such passive security measures the teams avoid having the FARP directly detected by radar.

Because of the volume of aircraft traffic and their importance to helicopter operations, FARPs should also be kept beyond medium artillery range. When located farther (forward), they must be displaced often to minimize this threat.

The site of a FARP must not only be masked from possible radar detection, but must have sufficient space to service helicopters as they rearm and refuel.

L.1.2 Objective. The ultimate objective of operating aircraft FARPs is to decrease response time and decrease turn-around time in support of sustained operations. This is achieved by minimizing flight time to and from the refueling and rearming point and reducing the refueling and rearming time. At the present time, refueling can be accomplished in about 10 to 15 minutes and rearming in 20 to 30 minutes. Rearming time is, therefore, the overriding factor. All times are, of course, dependent on environmental factors, aircraft armament and personnel proficiency.

L.1.3 Redeployment of a FARP. The effects of differing intensities of conflict will impact on the requirements for fluidity and mobility as the intensity of conflict escalates from lower intensity to higher intensity. In a high-threat environment there will be a continuing and relatively larger requirement for rapid displacement of the FARP. Multilocation operations, while closing out of one FARP and opening another, will be common. This mobile jump capability provides the commanders with increased responsiveness. Average time in one location will be situation-dependent based on the enemy's capability to detect and react.

The *new* FARP will be emplaced by the mode(s) of transportation most appropriate and/or available dictated by the urgency of the mission. Based on fuel and ammunition use rates, the *old* FARP will cease to be supplied at time *X*, and supplies will begin to be delivered to the new FARP. If time-situation will not allow the old FARP to *dry up*, some of the supplies needed at the new location will be transported from the old. The new FARP must be completely operational before the old is allowed to be displaced. Desired establishment time of the new segment must be estimated as closely as possible so supplies can be spotted, *backloaded*, etc., to allow movement of the material handling equipment to the new location sufficiently in advance of its opening time to preclude problems.

If only a portion of a FARP is to be moved, many of the preceding principles apply. A portion of the FARP may be jumped to support a specific tactical situation.

Of prime importance is the speed with which a FARP or a portion thereof can be placed into full operation, and later disestablished and moved to a new location. The system should be so designed that a trained team could be disembarked by ground or air transportation, commence operation in a brief period of time and then, on order, pack up and move out in a like manner without leaving debris, equipment, fuel, or ammunition behind. If at all possible, movement should be accomplished during lulls or between operations. With responsiveness of this sort, the required flexibility can be achieved, and degradation in capability is reduced.

L.2 FLIGHT OPERATIONS

L.2.1 Air Traffic Control. Positive control should exist at the FARP. Individual flight leaders may be required to provide separation as required. Helicopter Support Team (HST) personnel should provide terminal guidance with hand and arm signals, NVG compatible wands, or a GAIL system. An LZ control officer should provide positive control of all aircraft via radio, light signals, or hand and arm signals.

L.2.2 Flight Patterns. A 200-foot, left-hand *Charlie* pattern is normally desired for the landing pattern. During day operations, if the FARP is not being utilized, approaching aircraft will normally be cleared direct to a landing point short of the first refueling point via radio communications or hand and arm signals. If all refueling points are being utilized, aircraft should land at a pre-refueling staging area approximately 300 to 500 feet short of the first refueling point. Aircraft should utilize pre-refueling staging areas and post-refueling staging areas in order to maintain division/section integrity during pre- and post-refueling/rearming periods. Pre- and post-refueling staging areas should also be used for the embarkation and debarkation of troops loaded on transport helicopters. During night operations, all inbound aircraft should land at the pre-refueling point. Utilization of the pre- and post-refueling staging areas will reduce the number of airborne aircraft in the vicinity of the FARP.

L.2.3 Taxi Procedures and Signals. After landing at the landing point, the aircraft should await hand and arm or light signals before proceeding to a specific refueling point. Taxi will normally be accomplished by hovering to the farthest refueling point. Landings abeam the refueling points are allowed if directed by HST directors. During extremely dusty conditions only one aircraft at a time should hover/taxi in order to reduce visibility restrictions.

L.2.4 Radio Capabilities and Procedures. The LZ control officer and HST personnel at the FARP should be equipped with a PRC 77 and PRC 75 radio. Radio transmissions should normally not be made by aircraft while they are refueling, re-arming, dearming, or when they are within 50 feet of an aircraft undergoing any of the above evolutions. Emergency transmissions may be made as required.

L.2.5 Refueling Procedures

1. Helicopter refueling should be accomplished by utilizing the following procedures:

   (a) Hot refueling — the term hot refueling is used to describe refueling with the aircraft engine(s) operating. Only aircraft that are equipped with a closed circuit refueling receiver that incorporates an automatic fuel shutoff capability are authorized to hot refuel.

   (b) Cold refueling — this is accomplished by shutting down the engines, turning off all switches, and waiting until the rotor blades have stopped turning and are secured. Refueling is then normally accomplished by open port refueling.

2. All aircraft should utilize closed circuit refueling if the aircraft and the FARP are suitably equipped.

3. All aircraft carrying ordnance/passengers should be downloaded/dearmed/debarked prior to repositioning at the refueling points.

4. Open port hot refueling is not authorized at any time.

L.2.6 Postrefueling Procedures. Aircraft should not depart refueling points until cleared by HST directors. Aircraft may remain in the FARP in order to retain section integrity or depart singly and rendezvous with their division/section leader in the postrefueling staging area. Aircraft commanders should ensure proper postrefueling procedures and pretakeoff check lists are completed prior to takeoff.

L.2.7 Night Operations

1. FARP operations during night conditions will normally be set up for night vision goggle operations. The GAIL system will normally not be available and will require a reconfiguration of the lighting in the FARP. The GAIL position lights, with blue filters, may be utilized. A minimum of 22 position lights are required for the FARP and dearming area. The glidepath indicator is not compatible with NVGs. Cyalume illuminating lightsticks (Chemlight) may be utilized in place of GAIL position lights.

2. All lighting during NVG operations should be compatible with the night vision goggles. Taxi directors should utilize wands with blue/green cones.

3. FARP position lighting should be as depicted in Figure L-1.

L.2.8 Prerefueling Staging Area. The prerefueling staging area is a landing area for aircraft to position themselves when all refueling points in the FARP are full. It can also be used for the discharge of embarked troops prior to refueling operations. This landing area should be within visual range of the FARP and be large enough to contain a division or more of aircraft. The use of the prerefueling staging area will preclude flights of aircraft orbiting the FARP. HST director support will normally not be available at the the prerefueling staging area. The location and lighting of the prerefueling and postrefueling staging area is depicted in Figure L-1.

L.2.9 Postrefueling Staging Area. The postrefueling staging area is a landing area for aircraft to position themselves after they have refueled and are waiting for wingmen or joining their section/division flight. It is also

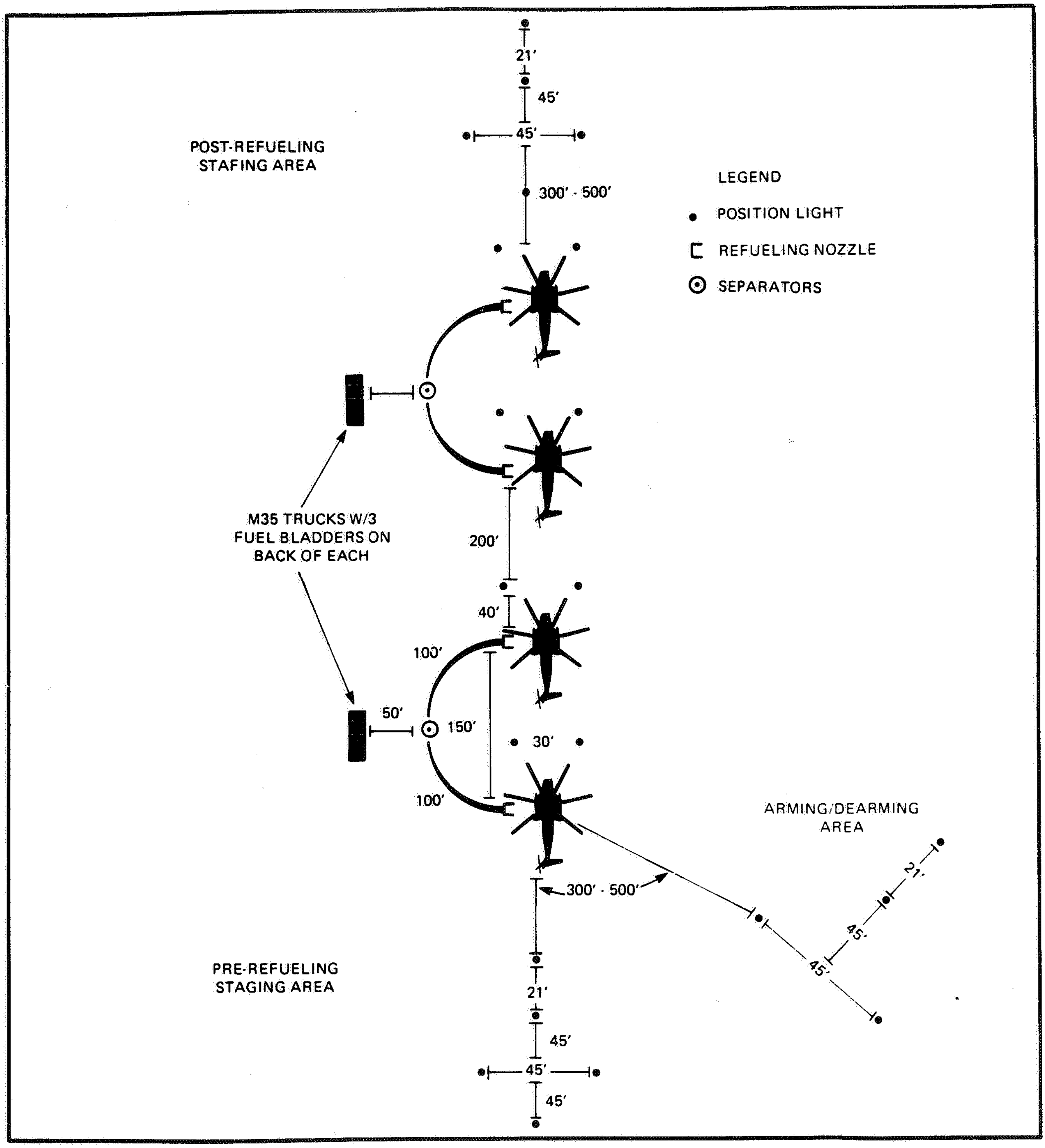


Figure L-1. FARP Layout

used for the loading of previously debarked troops. prefueling and postrefueling staging area locations should be thoroughly briefed and understood by all aircrews who will utilize the FARP. HST director support will normally not be available at the postrefueling staging area.

L.3 FARP EQUIPMENT AND LAYOUT

L.3.1 Site Preparation. FARP personnel should clear away loose debris that could be disturbed by rotorwash and pose a danger to aircraft or personnel. The site should be cleared (no depression or protrusion exceeding 10 inches) level (maximum slope angle should not exceed 5°) and possess soil conditions that will result in minimum dust/soil disturbance by hovering helicopters.

L.3.1.1 FARP Size. Detailed distances and separation between landing/refueling points are depicted in Figure L-1.

L.3.1.2 FARP Equipment. The FARP should normally utilize the equipment from the Helicopter Expeditionary Refueling System.

Note

> In order to decrease refueling time, consideration should be given to the acquisition of a 350-gpm pump.

L.3.1.3 Site Layout. The layout of the FARP should be planned around the following six factors:

1. Spacing between aircraft — the space between refueling points must be planned to accommodate the largest helicopter planning to utilize the FARP. Normally, all types of helicopters refuel at the FARP. Therefore, the standard layout should accommodate aircraft in size up to the CH-53E.

2. Wind direction — the FARP should be laid out so the helicopters can land, refuel, and take off into the wind.

3. Vapor collection — fuel vapors are heavier than air and will pool in a depression or hollow. If the site slopes, lay out FARP equipment on the higher ground.

4. Drainage — do not lay out the equipment in a place where a spill will drain into an area where equipment is located or into a refueling point.

5. Camouflage — due to the possibility of having to move, nets or other types of concealment may not be of any signficant advantage. When possible, place the pumps, filter/separator, and fuel bladders in woods, along a hedge row, or in positions where natural shadows will disguise the shadow patterns of the equipment. It may be possible to conceal most of the hoses in woods, with the nozzles hung on hangers at the edge of the tree line. Deep grass can be bent over the hoses to help conceal them. If necessary, use heaped dirt or large rocks to break up the characteristic straight shadows of the suction hoses. Remember that shadow patterns change during the day; move your equipment, if necessary, to use these changing patterns.

6. Obstacles — approach and departure routes must be planned around the lowest obstacles and into the wind.

L.3.2 Personnel Requirements

1. TAFDS — in order to man four refueling points, nine personnel are normally required.

2. HST — one director is required for each operating refueling/landing/dearming point. This will normally require five directors.

3. Ordnance — a minimum ordnance crew of four trained ordnance men are normally required during any arming/dearming or loading/downloading sequence involving attack helicopters.

L.4 ORDNANCE PROCEDURES

L.4.1 General

1. Aircraft should not be refueled with armed ordnance aboard. All ordnance should be downloaded in the dearming area prior to refueling. Appropriate grounding points should be utilized in each arming/dearming area.

2. The arming/dearming area location should be briefed to all aircrews utilizing the FARP.

3. All appropriate NATOPS arm/dearm check lists should be utilized during all ordnance evolutions.

L.4.2 Ordnance Safety. Safety precautions for each type of munitions and handling equipment are contained in NAVAIR publications and OPNAV instructions and should be strictly adhered to.

1. Smoking should not be allowed within 100 feet of any form of ordnance or within 100 feet of an aircraft loading/downloading ordnance.

2. A qualified ordnance safety observer should be present to observe all phases of ordnance evolutions being conducted.

3. The arming/loading area should be located a minimum of 300 feet from the refueling area.

4. The arming/loading area should be positioned so that an aircraft loaded with ordnance will not point the nose of the aircraft at the refueling area during landings, takeoffs, or during arming/dearming.

L.5 SAFETY

L.5.1 General Safety

1. Safety is the responsibility of all personnel and shall be the determining factor before, during, and after all evolutions involving class V(A) munitions and refueling operations. Any unsafe situation, practice, or procedure observed by any person should immediately be brought to the attention of all hands and all ordnance/refueling evolutions should immediately stop until the unsafe condition can be eliminated.

2. To provide adequate protection there should be a minimum of one fire extinguisher (20b:C rating) at each nozzle and pumping unit.

L.5.2 Emergency Fire and Rescue Procedures. The following general procedural steps are guides to what FARP personnel should do in a fire or crash emergency. So much depends on the specifics of each emergency situation that only basic reaction steps can be outlined. The best preparation for coping with an emergency is the firefighting and crash-rescue training that all refueling personnel should have received.

1. Ground crew — in case of fire or a crash or other accident that could lead to fire, members of the ground crew should:

   (a) Stop the flow of fuel — close the nozzles, shut down the pump, close the valves in the refueling system, and, if possible, uncouple the hoselines between the tanks and pump.

   (b) Free the aircraft — if possible, separate all aircraft being refueled from the fuel lines. Disconnect the nozzles and grounding wires so aircraft can lift off and become clear of the danger area, if necessary.

(c) Give the alarm — give the alarm by using the emergency alarm system that has been established at the refueling point. The HST director can direct approaching aircraft away from the danger and can, if necessary, direct aircraft on the ground to lift off in a safe and orderly manner.

(d) Attempt rescue and contain fire — if the emergency is a crash or if the fire involves an aircraft, the most immediate need is to see that all personnel are out of the aircraft. Attempt the rescue immediately, using firefighting equipment as necessary to approach the aircraft and to provide a fire-free escape route for aircrew members. No one else should be in the aircraft during refueling, but in a crash the full crew and passengers may be aboard. After all personnel are out of the aircraft, fight the fire. Attempt to isolate and control it until it is extinguished or help arrives.

2. Aircrew of turning aircraft — a member of the air or ground crew should be manning the nozzle fire extinguisher. The crew chief should be supervising the refueling operation and be on the intercom to the pilot. In case of a fire that involves the aircraft, the pilots should shutdown the engines and get out of the aircraft as quickly as possible. The person manning the nozzle fire extinguisher should use it immediately, first to assure the pilots an escape route, and second, to extinguish or isolate the fire.

3. Aircrews of other aircraft — the ground crew will shut off the flow of fuel and disconnect the hoselines and grounding cables from all aircraft. The pilot of each aircraft that is not involved in the fire or emergency should bring his engines up to operating rpm as quickly as possible. He should lift off and move away from the danger, either at the direction of the HST director (in situations where several aircraft are at the refueling point) or independently (in situations where his is the only aircraft or where he can clearly see the movements of all other aircraft). Aircrew members should remain on the ground to assist with rescue and firefighting efforts, using equipment available at the site. If the emergency is a crash in the FARP, other aircraft should prepare to lift off immediately.

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